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TRANSPORTATION CONTROL STRATEGIES FOR THE STATE IMPLEMENTATION PLAN CITY OF PHILADELPHIA

Fred Winkler

TRW Transportation and Environmental Operations

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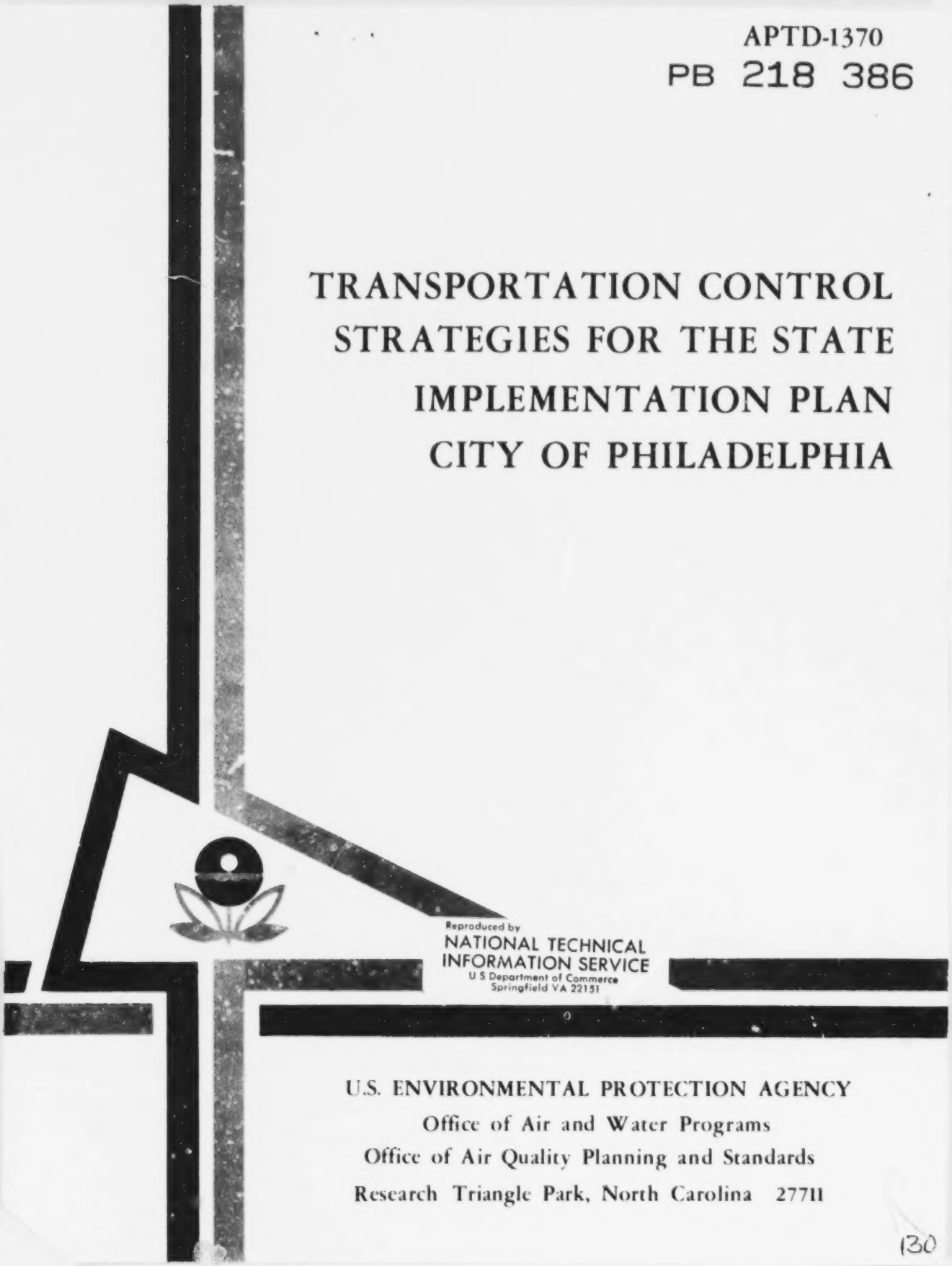

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The document demonstrates the nature of the Air Quality problem attributed to motor vehicle operation, the magnitude of the problem and a strategy developed to neutralize these effects in order that National Ambient air quality standard may be attained and maintained.

17. Key Words and Document Analysis. 17a. Descriptors

Motor Vehicle emitted pollutants - air pollutants originating within a motor vehicle and released to the atmosphere.

National Ambient Air Quality Standards - Air Quality Standards promulgated by the Environmental Protection Agency and published as a Federal Regulation in the Federal Register.

17b. Identifiers/Open-Ended Terms

VMT - Vehicle Miles Traveled
Vehicle Mix - distribution of motor vehicle population by age group.
LDV - light duty vehicle - less than 6500 lbs.
HDV - heavy duty vehicle - greater than 6500 lbs.

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Prepared By

TRW Transportation & Environmental Operations
Environmental Services
7600 Colshire Drive
McLean, Virginia 22101

Contract No- 68-02-0048

EPA Project Officer: Fred Winkler

Prepared for

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Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

February 1973

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1.0 INTRODUCTION

The State of Pennsylvania must submit definitive transportation control plans to the Environmental Protection Agency (EPA) no later than February 15, 1973, for those areas of the state, namely Philadelphia and Pittsburgh, where emissions from transportation sources have resulted in concentrations of pollutants in excess of the national ambient air quality standards. To assist the state in its preparation of this transportation plan, EPA has awarded a contract to TRW Inc., and its subsidiary, De Leuw, Cather and Company, for developing the strategies for Philadelphia that will achieve carbon monoxide air quality standards required to be met by the year 1977.

2.0 SUMMARY

2.1 AIR QUALITY

The second highest measurement of carbon monoxide concentration during 1971 was 22.5 milligrams per cubic meter eight-hour average measured at 20th and Race Streets. The national primary standard of 10 milligrams per cubic meter eight-hour average must be achieved by July 1977.

2.2 EMISSION REDUCTION REQUIRED

A reduction of 56 percent from 1971 emission levels of CO emitted from mobile sources throughout the City is estimated to be needed to achieve the required reduction in ambient air concentrations to the level of the standard. Estimated mobile source emissions of CO in 1971 was 302,000 tons per year total for the City and 25,500 tons per year for the Central Business District (CBD). By 1977, it is estimated that emissions must be reduced to 133,000 tons per year. With no transportation control strategy implemented, it is estimated that a 47 percent reduction will be achieved total for the City and 61 percent for the CBD, due largely to the effect of Federal new car emission controls.

2.3 CONTROL STRATEGY

2.3.1 Control Measures

Control measures which can be used to reduce mobile source emissions and their estimated effects are as follows:

Inspection/Maintenance - One of several inspection alternatives needed to maintain engine performance and emission controls at lower emission levels. Estimated reduction: 4 - 6 percent.

Inspection/Maintenance with Retrofit - One of the several inspection alternatives with the additional requirement that all pre-1968 vehicles be retrofitted with emission control devices comparable to new vehicle emission controls. Estimated additional reduction is less than 1 percent.

Curbside Parking and Loading Regulations -Enforcement of regulations in order that programmed TOPICS traffic controls are effective. Estimated reduction: 3 percent for the CBD.

Electrification - Replacement of motor buses with electrified vehicles results in an estimated reduction of less than 1 percent.

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Gaseous Fuel Conversion - Emission rates expected from gasoline fueled 1975 model years and beyond compare favorably with those rates from gaseous fueled vehicles. Conversion of pre-1975 fleet vehicles would have short-term, negligible effect.

Increase Mass Transportation Ridership - Control measures which have the potential for increasing ridership are as follows:

- Center city tunnel connection of suburban rail stations
- Additional park and ride facilities
- Capacity increases
- Shorter headways
- Security force to eliminate crime in stations and transit cars
- Rider amenities (appearance, lighting, better seating, station upgrading)
- Unified fare system
- Work staggering in CBD
- Circumferential transit
- Commuter rail and subway extensions

Ridership increases from 1 percent to 20 percent are estimated to reduce emissions from less than 1 percent to 7 percent

Restraints - Possible restraints are the prohibition of certain classes of vehicles from congested areas (congestion pass) and parking space control for inhibiting the movement of vehicles into areas where limited parking is available. A prohibition of 100,000 vehicle trips per day are estimated to reduce emissions 2 percent.

VMT Controls - The responsible planning agencies should factor air quality effects into their transportation planning.

CBD Priority - The priority to those control measures which preferentially control emissions from the CBD or other yet to be determined areas of high pollutant emission density.

Car Pools - Low density population in the suburban areas discourages utilization of car pools as an attractive transit mode.

Vehicle Free Zones - Attractive pedestrian malls have the potential for helping to revitalize center city commerce. However, experience in other urban areas has shown that displaced vehicular traffic tends to be relocated rather than reduced.

2.3.2 Control Strategy Selection

Selection requires the consideration of comparative cost effectiveness of the alternative control measures and the technical and institutional obstacles. Data was available for only a limited analysis of cost effectiveness. Emission related control measures, such as inspection/maintenance programs, have technical limitations which need to be overcome and also have substantial cost effective deterrents. VMT reduction control measures, such as mass transit improvements and traffic restraints, present funding problems for the intensive network required in the case of mass transit and severe institutional obstacles in the case of traffic restraints. Traffic restraints should not be implemented without alternative means of travel by mass transit.

Control measures are needed to reduce mobile source emissions by 26,000 tons CO per year (9 percent). The recommended control strategy for Philadelphia is as follows:

Curbside Parking and Loading Regulations - Estimated to achieve a reduction of 4000 tons/year.

Inspection/Maintenance (Engine Parameter Without Retrofit) - Estimated to achieve a reduction of 10,000 tons/year

Increase Mass Transportation Ridership - Potential reductions of 6000 tons/year to 10,000 tons/year are estimated for a 10 percent increase in ridership.

Restraints - Prohibition of certain classes of vehicles from congested areas are estimated to result in a reduction of 6000 tons/year per 100,000 daily vehicle trips.

VMT Controls - Factor effect of increase of vehicular miles of travel on air quality into transportation planning.

CBD Priority - Give priority to those control measures which preferentially control emissions from the CBD or other yet to be determined congested areas.

With substantial increases (more than 10 percent) in mass transit ridership, it is estimated that the air quality goal can be achieved by implementation of the first three control measures listed. However, considering the time constraints and economic obstacles to implementation of most of the mass transit control measures, traffic restraints at least for the short term are likely to be needed.

2.4 DATA LIMITATIONS

The technical approach had to be adjusted to minimize the effects of data limitations. The analytical limitations fall into two categories:

- Inability to define control requirements or effects within acceptable confidence limits.
- Lack of demand/response models for analyzing public response to certain control measures.

A prime example of the first category is the limited amount of air quality data available for defining a carbon monoxide base level from which the required reductions must be made. The required reductions are very sensitive to the uncertainties in the air quality data base. An example of the second category is the uncertainty of response of the auto driving public to the implementation of control measures for increasing ridership on public transportation.

Where data was unavailable or its validity questionable, the approach during this study has been to provide for contingencies in the control strategy to allow for the possible error in the projections and the predictions of effects caused by possible inaccuracies in the data base and limitations of the analytic technique. Additionally, it is recommended that work begin immediately to establish the more reliable data base and to provide the bases for adjusting the control strategy if necessary to achieve the required results. Preference ranking has been limited only to those control measures where clearcut choices seem to be available to the State.

2.5 CONTROL STRATEGY IMPLEMENTATION

Two concurrent implementation tasks requiring immediate action are the studies and surveys required to make the necessary corrections and additions to the data base, and immediate decision mass transit funding. Following update of the data base, a better defined mass transit improvement program may require additional funding (deferred decision funding). Funding delays may prevent the implementation of all of the required mass transit control measures within the time constraints.

2.6 EFFECTS ON OTHER EMISSION PARAMETERS

Control strategy for the reduction of carbon monoxide from mobile sources has a comparable effect on hydrocarbon emissions and thus corresponding reductions in photochemical oxidants are projected. Increased average speeds from the implementation of TOPICS traffic controls or VMT reductions may result in an increase in nitrogen dioxide emissions per mile traveled but this emissions/average speed relationship has not been quantified to date[7].

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[7] D. S. Kircher and D. P. Armstrong, "An Interim Report on Motor Vehicle Emission Estimation," Environmental Protection Agency, October 1972.

3.0 PROGRAM PURPOSE AND DESCRIPTION

3.1 REGIONAL DESCRIPTION

3.1.1 Air Quality Objectives

The region for which this transportation control strategy has been developed is the County (City) of Philadelphia. Philadelphia is the major city of the Metropolitan Philadelphia Interstate Air Quality Control Region (AQCR). This AQCR is comprised of the counties of Bucks, Chester, Delaware, Montgomery and Philadelphia in Pennsylvania; the counties of Burlington, Camden, Gloucester, Mercer and Salem in New Jersey; and the county of New Castle in Delaware. The Administrator of the Environmental Protection Agency (EPA) has approved those portions of the Implementation Plan submitted by the State of Delaware which relate to the attainment of national ambient air quality standards in the Delaware portion of the Metropolitan Philadelphia AQCR. Attainment dates are as follows:

- Nitrogen dioxide — January 1974
- Carbon monoxide — January 1974
- Photochemical oxidants (hydrocarbons) — Air quality levels presently below secondary standards

The Administrator has also approved those same portions of the Implementation Plan submitted by the State of New Jersey or has proposed specific dates for the attainment of the relevant standards for New Jersey's portion of the same AQCR. Attainment dates submitted or proposed are:

- Nitrogen dioxide — From plans approved or promulgated 3 years
- Carbon monoxide — 5 years
- Photochemical oxidants (hydrocarbons) — 5 years

The Administrator has also approved those same portions of the Implementation Plan submitted by the State of Pennsylvania or has proposed specific dates for the attainment of the relevant standards but with the additional requirement that a transportation control strategy be submitted by February 15, 1973, for attainment of the national ambient air quality standard for carbon monoxide by July 1977. Attainment dates are as follows:

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• Nitrogen dioxide	3 years from plans approval or promulgation
• Carbon monoxide	July 1977
• Photochemical oxidants (hydrocarbons)	3 years from plans approval or promulgation

It is the objective of this study to develop transportation control strategies which achieve compliance with the ambient air quality standard for carbon monoxide by the attainment date. Further, it must be demonstrated that these transportation control strategies will not result in higher levels of nitrogen dioxide or photochemical oxidants or in any way prevent the State from achieving compliance with the ambient air quality standards for these pollutants.

3.1.2 Air Quality

National air quality standards[1A] in effect are as follows:

- Carbon Monoxide - 10 milligrams per cubic meter (9 ppm) maximum eight-hour concentration not to be exceeded more than once per year, and 40 milligrams per cubic meter (35 ppm) maximum one-hour concentration not to be exceeded more than once per year. Primary and secondary standards.
- Hydrocarbons - 160 micrograms per cubic meter, (0.24 ppm) corrected for methane, maximum three-hour concentration (6 to 9 a.m.) not to be exceeded more than once per year. Primary and secondary standards.
- Nitrogen Dioxide - 100 micrograms per cubic meter (0.05 ppm) annual arithmetic mean. Primary and secondary standards.

The second highest CO concentration, eight-hour running average measured in Philadelphia during 1971 was 22.5 milligrams per cubic meter[1B] from 5 p.m., October 16 to 1 a.m., October 17. The second highest running average has been prescribed by EPA as the basis for determining compliance with standards. The measurements were made at 20th and Race Streets in

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[1A] Federal Register, April 30, 1971.

[1B] Data obtained from EPA.

the Central Business District (CBD). No other air quality monitoring sites with CO measurement capability were operational in 1971. The City's Air Management Services department is installing a network of ten CO monitors which should be operational during 1973.

It is recognized that measurements from only one receptor site are a poor basis for determining the magnitude of compliance or non-compliance with air quality standards. The site is believed not to be in the area of maximum CO emissions for either the City or the CBD. Thus, there is a high probability that measurements at other receptor points will yield higher levels of concentrations.

3.1.3 Demography

Population of the nine-county Pennsylvania-New Jersey region (counties of Bucks, Chester, Delaware, Montgomery and Philadelphia in Pennsylvania and Burlington, Camden, Gloucester and Mercer in New Jersey) compiled from 1960 and 1970 census data is as follows:

	1960	1970
Total nine-county region	4,609,289	5,121,882
Philadelphia	2,002,512	1,948,609

3.1.4 Vehicle Population

Auto ownership[1C] in the nine-county region and in Philadelphia was as follows:

	1960	1970
Nine-county region	1,243,656	1,587,579
Philadelphia	399,962	463,193

(1C) Data provided by the Delaware Valley Regional Planning Commission.

3.1.5 Areas of Congestion

The most likely major areas of congestion are as follows:

- Center City (bounded by Spring Garden on the north; South Street on the south; the Schuylkill and Delaware Rivers on the west and east), with heaviest congestion in the core (Race, 7th, Locust, and 18th Streets).
- Schuylkill Expressway south of City Line Avenue.
- Roosevelt Boulevard east of Schuylkill Expressway.
- Penrose Avenue - 26th Street intersection.
- City Line Avenue west of Schuylkill Expressway.
- Walnut-Chestnut Street one-way couplet west of Schuylkill Expressway.
- Broad Street south of Roosevelt Road.
- Assume other outlying areas considered for TOPICS improvements to a lesser degree.

3.1.6 Limited Access Highways and Delaware River Crossings

I-95 (Delaware Expressway) is completed within the region as follows:

- From southern boundary of region to Chester.
- From Girard Avenue north to the northern boundary of the region.

The remaining link, from Chester to Girard Avenue, is expected to be open to traffic by 1976. Completion of this link will no doubt result in significant increases in through traffic in Philadelphia as well as diversion of local and commuter traffic from other streets and highways. I-95 within Philadelphia generally follows the Delaware River and the eastern edge of the CBD.

I-476 (Mid-County Expressway) has a short section complete and two other short sections under construction in the vicinity of the Schuylkill Expressway. The remaining portions of this route which will tie the Pennsylvania Turnpike at its Northeast Extension with I-95 just north of Chester is not expected to be opened to traffic until 1976.

I-295. Remaining links within the region are expected to be completed by 1976. This highway will parallel the New Jersey Turnpike and is expected to reduce turnpike traffic.

Schuylkill Expressway extends from southeast Philadelphia at the Walt Whitman Bridge to the northwest where it connects with the Pennsylvania Turnpike at King of Prussia. This highway is a major artery for local and commuter traffic. It follows the Schuylkill River along the western fringe of the CBD.

Roosevelt Boulevard (U.S.1) connects with the Schuylkill Expressway near Allegheny Avenue and runs northeast, connecting with the Pennsylvania Turnpike. The western end of this major artery is limited access.

The Pennsylvania Turnpike is an east-west toll facility passing through Bucks and Montgomery Counties north of Philadelphia.

The New Jersey Turnpike is a toll facility which for many years has been the major through highway from New York City to the south. It passes through Gloucester, Camden and Burlington Counties.

The North-South Freeway in New Jersey extends from the Walt Whitman Bridge to the southeast toward Atlantic City.

The Walt Whitman Bridge is a toll facility operated by the Delaware River Port Authority (DRPA) that crosses the Delaware River from southeast Philadelphia into New Jersey and connects with the Schuylkill Expressway.

The Ben Franklin Bridge is a toll facility operated by DRPA that connects the CBD with Camden, New Jersey. It also serves as a crossing for DRPA's Lindenwold Line (commuter rail line).

The Tacony-Palmyra Bridge is a toll facility charging virtually negligible tolls (five cents) that connects Levick Avenue in lower northeast Philadelphia with New Jersey.

The Pennsylvania Turnpike Bridge extends this toll facility into New Jersey for connection with the New Jersey Turnpike.

The Scudder Falls Bridge is the crossing for Interstate 95 north of Trenton.

The Chester Bridgeport Bridge is under construction south of Philadelphia which along with a highway link connecting it to I-95 should be open by 1975. It will be a toll facility operated by DRPA and will tie I-95 with I-295.

The Delair Bridge will tie I-95 with U.S.130 in the northeast. It is also expected to be open in 1975 and will also be a toll facility operated by DRPA.

3.1.7 Public Transportation

Philadelphia has an established mass transportation system with a good modal mix. While much of the equipment and facilities need to be modernized to attract more riders, some modes of transit have capacity ridership during peak hours while others operate at well below capacity. With the establishment of Southeastern Pennsylvania Transportation Authority (SEPTA) as a single authority to manage major elements of the transportation system, integrated planning for transit extensions and for increasing capacity is possible. In addition to SEPTA's system, the Delaware River Port Authority through its wholly owned subsidiary Port Authority Transit Corporation (PATCO), operates a rapid transit system (The Lindenwold Line).

SEPTA's system consists of the following:

- Penn Central Railroad commuter rail lines into the surrounding Pennsylvania counties and terminating in the CBD at 16th and John F. Kennedy Boulevard.
- Reading Railroad commuter rail lines into the surrounding Pennsylvania counties and terminating in Reading Terminal at 12th and Market Streets.

- The Broad Street Subway, a north-south subway line from a northern terminus at Fern Rock to Snyder Avenue.
- The Market Street-Frankford Subway and Elevated is an east-west line from the western terminus at 69th Street to the eastern edge of the CBD. The line then turns north and runs elevated to Frankford in the near northeast.
- An extensive motor bus system throughout the City and into adjoining Pennsylvania counties.
- Some streetcar and trackless trolley routes.

PATCO's Lindenwold Line is a rapid transit rail line from Lindenwold, New Jersey, to 16th and Locust Streets in the CBD.

Transport of New Jersey, a privately owned bus company, has been providing bus transportation from New Jersey into Philadelphia. During 1972, certain transport of New Jersey bus routes will be reoriented as a feeder system for the Lindenwold Line.

Extensive public transportation improvements are scheduled for completion between now and 1980. Some of these improvements will be completed and will have a potential impact on the air quality by the attainment date for meeting the air quality standards of July 1977. The public transportation improvements programs are detailed in Appendix B.

3.1.8 The Central Business District (CBD)

The boundaries are Spring Garden Street to the north, South Street to the south, Schuylkill River to the west, and the Delaware River to the east. The approximate area is 2.9 square miles out of a total area for the entire City of 127 square miles.

3.2 PROBLEM DEFINITION AND DESCRIPTION

The national primary ambient air quality standard for carbon monoxide (CO) of 10 milligrams per cubic meter, eight-hour average, is exceeded in Philadelphia. The second highest concentration observed during the year 1971 was 22.5 milligrams per cubic meter. The measurements were made at a monitor located at 20th and Race Streets. The State of Pennsylvania

must develop and implement a transportation control strategy which has as its goal a reduction of CO concentration from the level measured in 1971 to or to less than the level of the air quality standard by July 1977.

The major impact on concentrations of CO in the ambient air comes from mobile source emissions. Stationary sources contributed only 14.6 percent to total CO emitted during 1971. Controls will be implemented by mid-1973 which will reduce the stationary source emissions by about 75 percent.

3.3 TECHNICAL APPROACH

Transportation control measures must be defined that will reduce mobile source emissions to a level which achieves compliance with the air quality standard by July 1977. The technical approach is to select candidate control measures and quantify where possible the emissions reductions expected. Comparisons of the candidate control measures are then made in relation to cost effectiveness and in relation to the technical and institutional obstacles to the implementation of the control measure. From these comparisons, a preference ranking is generated to aid in the selection of the most effective control strategy. However, limitations in the data available and in the analytic method used became obvious during the course of this study, (see subsection 3.4) following.

The technical approach had to be adjusted accordingly to minimize the effects of these limitations. The analytical limitations fall into two categories.

- Inability to define control requirements or effects within acceptable confidence limits.
- Lack of demand/response models for analyzing public response to certain control measures.

A prime example of the first category is the limited amount of air quality data available for defining a carbon monoxide base level from which the required reductions must be made. The required reductions are very sensitive to the uncertainties in the air quality data base. For Philadelphia, a $\pm$ 10% error in the air quality base results in a $\pm$ 36%

variation in the required reductions needed from the implementation of control measures. An example of the second category is the uncertainty of response of the auto driving public to the implementation of control measures for increasing ridership on public transportation. Not only does this prevent an accurate estimate of the effect of the control measure on air quality, it also thwarts any attempt at analyzing its cost effectiveness.

Where data was unavailable or its validity questionable, the approach during this study has been to provide for contingencies in the control strategy to allow for the possible error in the projections and the predictions of effects caused by possible inaccuracies in the data base and limitations of the analytic technique. Additionally, it is recommended that work begin immediately to establish the more reliable data base and to provide the bases for adjusting the control strategy if necessary to achieve the required results. Preference ranking has been limited only to those control measures where clearcut choices seem to be available to the State.

3.4 LIMITATIONS OF THE TRANSPORTATION CONTROL STRATEGY ANALYSIS

3.4.1 General Concepts

The basic requirement which any acceptable air pollution control strategy must meet is that emission levels following implementation of the strategy are consistent with the attainment and maintenance of National Ambient Air Quality Standards. Satisfaction of this requirement depends upon a detailed knowledge of current air quality levels and a quantification of the pollutant emissions in the region. Additionally, an implementable transportation control strategy must consider the economic factors associated with its adoption and also the social and political changes necessary to accommodate each specific control measure. The air quality benefits of any action must be thus balanced against the social and economic dislocations caused by its implementation. Long-term regional transportation goals and policies must be balanced against the need to achieve specific degrees of emission reduction by 1977. Limitations in the data available and in the analytic method used became obvious

during the course of this study, and care must be taken in the interpretation and evaluation of the control strategy recommendations contained in this report. Several specific areas in which the present study needs to be confirmed and validated by future study are listed below.

3.4.2 Air Quality Monitoring

Two basic areas of concern appear in connection with air quality data available for this project. First and most important, ambient monitoring at only one point completely fails to give an adequate appreciation of the regional character of the air pollution problem. It is impossible to determine whether the monitor is being adversely affected by local sources and thus giving unrealistically high readings in terms of the regional problem or conversely, whether there are areas of maximum ambient pollution that are being completely unmonitored. The only solution to this problem lies in increasing the number and geographical spread of ambient monitors. Data from the extended monitoring network should be used to constantly evaluate and update the control strategy presented in this document. The second problem concerning the use of air quality monitoring data lies in the statistical manipulations and projections used to determine the required level of reduction for the attainment of standards. Basing an extensive control program on measurements obtained in one or two hours per year may lead to the imposition of unduly strict control measures. The trend of ambient measurements during the period before the target year of 1977 must be carefully watched and used to adjust control measures according to observed ambient conditions. Further, specific high measurements obviously due to adverse meteorological conditions may be considered as episode control situations and may not require the imposition of long-term transportation control strategies for their solution.

3.4.3 Emission Factors

The mobile source emission estimates utilized in this study are based upon the best currently available emission factor estimates. These emission estimates are in the process of updating and revision with both in-use and new vehicle testing programs, conducted by the Environmental

Protection Agency. The applicability of the standard test driving cycle to the driving patterns in each metropolitan area is questionable. Further, there are many trip types making up the total vehicle miles traveled in each area; and it has not been possible on the basis of current available data to distinguish in an air pollution emissions sense between the different driving modes used. It is highly recommended that new emission factors be utilized as they become available to recompute and redefine the severity of the mobile source generated emission in the region. Finally, the emission factors used in the study relates speed to the emission only on the basis of the integrated driving cycle. This has prevented the accurate assessment of changes in emissions due to improved traffic flow characteristics in core, center city areas.

3.4.4 Cold Start Emissions

Preliminary data have shown that the emissions generated during the first few minutes of vehicle operations represent a large and increasing portion of the total emissions during any individual vehicle trip. The implications of this fact are that to truly reduce mobile source emissions it may be necessary to address the reduction in total vehicle trips rather than merely reducing the number of vehicles miles traveled. Unfortunately, the data relating to this phenomena were not sufficiently developed to be used in the analysis presented in this study. Another potential effect of high level cold start emissions from the control strategy might be in the control as a stationary source of parking structures. Again, it has not been possible to quanititatively describe the effect of this type measure on the regional air pollution problem in this report.

3.4.5 Traffic Data and Projections

Traffic data and traffic projections have not historically been collected with a view to the estimation of motor vehicle air pollution emissions. This fact has necessitated the reworking of traffic data including vehicle flows, speeds and modal mixes into the format necessary for emission calculations. Certain assumptions and potential inaccuracies have been introduced by this process. Further, the use of trends and

projections in vehicle growth have been prepared by various agencies and often little unanimity has been found concerning appropriate growth rates. These data in certain cases require that a close watch be maintained both on traffic changes and ambient air quality during the period between now and full strategy implementation so that any deviations from the expected vehicle emission rates can be determined and appropriate adjustments made in the control strategy. It should be noted that stationary source emission projections also suffer from inaccuracies in the projection of industrial growth and in the application of as yet untested control technologies to control of these stationary sources.

3.4.6 Analytic Techniques Used

The key analytic calculation performed in this study is the relation between emission levels and ambient air quality. Sufficient mobile source data were not available to utilize sophisticated mathematical modeling techniques in the development of this relation between emissions and air quality. Control strategy reductions were thus based on proportional rollback techniques relating existing emissions and air quality on a proportional basis. The use of modeling is highly recommended since it will both include the effects of local meteorological and topographical features and indicate, in a way that rollback estimation cannot, the geographical extent of the regional air pollution problem. Such modeling and simulation exercises using models currently under development should be carried out during the years between now and 1977 and should be used to modify, if required, the control strategy recommended in this document.

3.4.7 Effects of Control Measures

It was generally not possible to expressly quantify the emission reduction effect of many of the control measures considered in this document. For example, the effect of an inspection and maintenance program depends strongly upon the exact test procedure used, maintenance recommendations the quality and availability of trained mechanics and a host of other factors which were impossible to define exactly during this study. Similarly, mass transit improvements can be expected to reduce vehicle miles traveled within the region. The extent of this reduction is

unknown until specific data concerning the economic elasticity of the various travel demands, the modal split of trips within the region, and many other factors are determined. These parameters need to be carefully evaluated before the quantitative estimates become reliable.

3.4.8 Conclusions

It is strongly recommended that programs be instituted to provide additional data and to apply more sophisticated analytic techniques in the areas listed above. Work must begin upon the implementation of the required regional control measures; however, final implementation and enforcement should be dependent upon data collected during calendar years 1973, 1974, and even 1975. Full consideration must be given to the political, jurisdictional and social impact of all control actions. The control strategy presented in this document must be considered as an initial attempt to quantify the relationship between transportation processes and the regional air pollution problem. The further study indicated should be used to modify this baseline effort. The air pollution implications of the transportation process are very complex and a modification of this process can potentially effect significant changes in the social and economic character of the metropolitan region.

4.0 CONTROL STRATEGY DEVELOPMENT

4.1 EMISSION REDUCTION REQUIRED

A 56 percent reduction in the CO emitted from mobile sources was determined to be the reduction required to meet the national ambient air quality standards. A proportional model was used to determine the required emission reductions needed. The proportional model is described and the rationale for its use is detailed in Appendix A.

To determine the magnitude of the emissions reduction required, it is necessary that the quantitative effect of emissions reductions on the level of concentration in the ambient air be determined. Methods for determining this effect vary in complexity. The more complex and, with sufficient data base, the more representative of actual conditions are diffusion models which use for inputs the emission rates of all sources (e.g., all streets plus all stationary sources), the concentration at the receptors, and source-receptor interaction. The latter is determined from and varies with meteorological conditions. The least complex is the simple proportional model used in this study which assumes that the reduction in air quality concentration levels is directly proportional to emission reductions.

4.2 EMISSION ESTIMATES

4.2.1 Methods

An emission estimate is the product of two factors; vehicle miles of travel (VMT) times an emission rate (emission factor) in grams pollutant per mile traveled, yielding the mass rate of pollutant per unit of time. Emission factors were based on known or expected emission rates for each vehicle class considering age of vehicle, effectiveness of emission controls, average speed, and age distribution of the population of vehicles traveling within Philadelphia[7]. The impact of Federal new motor vehicle exhaust system controls required on present and future vehicles were considered. Emission factor calculations are detailed in Appendix A.

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[7] D.S. Kircher and D.P. Armstrong, "An Interim Report on Motor Vehicle Emission Estimation," Environmental Protection Agency, October 1972.

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The various elements which make up the emission factor, except for age distribution, are found in the above referenced report.[7] The emission rates in gram/mile are the results of tests for determining exhaust emission rates of light duty vehicles in Chicago and applied to the geographic area encompassing Philadelphia. The tests were by Federal test procedures on low mileage (4000 mile) nondeteriorated vehicles. Heavy duty emission rates were based on studies in a single geographic area.

The emission rates were adjusted for deterioration of the emission control devices with mileage. Limited data on deterioration for in-service light duty vehicles only was available for estimating deterioration factors. The deterioration rate of future emission control devices is not known and projections are largely dependent on the differences between new vehicle and in-use vehicle emission standards.

The emission rate is then adjusted to account for the expected annual travel as of December 31 of each model year of vehicle traveling in Philadelphia. The average annual mileage of each model year is weighted with the age distribution of vehicles traveling in the region, based on 1970 registration figures. The same age distribution was projected to 1976 and 1977 for predicting the emission factors for those years.

A weighted speed adjustment factor adjusts the emission rate for variation in speed. Carbon monoxide and hydrocarbon emissions vary inversely with vehicle speed. Unfortunately, the speed adjustment factor relates speed to the emission only on the basis of the integrated driving cycle. The speed effect of this driving cycle may not correlate too well with driving cycles imposed by congested city street driving conditions.

VMT and speed were determined as shown in Appendix B. Estimates of VMT and speed within Philadelphia and its CBD were based principally on historical projections. Citywide travel was based on known 1960 traffic projected by trends in auto ownership and screen line crossings. Travel within the CBD was based on trends reflected by cordon counts taken on its perimeter as well as a 1963 traffic flow map. Average speed on the major street system in 1960 was 20.5 miles per hour. An average speed of

12 miles per hour was assumed on the local streets. A 1971 travel time survey made by the DVRPC over selected routes within the region indicates a slight overall decrease in speeds between 1960 and 1971. Speed during 1971 within the City was thus assumed to be 20 miles per hour on the major street system with the same 12 miles per hour applicable on local streets. Overall average speed weighted by VMT was then calculated from these values. Average speed within the CBD was based on 1970 speed studies made by the City's Traffic Engineering Division.

VMT and speed projections to 1977 were based on actual growth reflected by census, interim traffic counts, available real life data and judgement based on national trends. The projections also reflect the expected effects of major highway projects programmed for completion by 1977. Details on these projections are shown in Appendix B.

4.2.2 Emission Estimates with Present Transportation System and Emission Controls (1971)

Estimated mobile source carbon monoxide emissions for 1971 were 302,240 tons per year overall for the City and 25,550 tons per year for the CBD. Emission factors and VMT by vehicle class used for these estimates are given in Table 4-1. The second highest eight-hour CO measurement that is used for baseline air quality data occurred October 16-17, 1971. This level of concentration must be reduced to the level of the air quality standard by July 1977. The CO emission rates in tons/year for 1971 is adjusted upward slightly from the year end values shown in the table to reflect VMT and emission factor projections back to October.

4.2.3 Emission Estimates with Programmed Transportation System and Emission Controls (1977)

Estimated mobile source carbon monoxide emissions for 1977 were 158,630 tons per year overall for the City and 10,040 tons per year for the CBD. Emission factors and VMT by vehicle class used for these estimates are given in Table 4-2.

Table 4-1. ESTIMATED EMISSIONS (1971 YEAR END)

LIGHT DUTY VEHICLES

	Emission Factor (gm CO/mi.)	VMT (10^3 mi./day)	CO Emissions (tons/year)
City Total	65.7	10122	267340
CBD	85.7	636	21910

HEAVY DUTY VEHICLES

	Emission Factor (gm CO/mi.)	VMT (10^3 mi./day)	CO Emissions (tons/year)
City Total	129.6	569	29640
CBD	169.2	48	3270

DIESEL

	Emission Factor (gm CO/mi.)	VMT (10^3 mi./day)	CO Emissions (tons/year)
City Total	20.4	77	630
CBD	20.4	7	60

Table 4-2. ESTIMATED EMISSIONS (1977 YEAR END)

LIGHT DUTY VEHICLES

	Emission Factor (gm CO/mi.)	VMT (10^3 mi./day)	CO Emissions (tons/year)
City Total	26.8	11094	119570
CBD	27.3	697	7650

HEAVY DUTY VEHICLES

	Emission Factor (gm CO/mi.)	VMT (10^3 mi./day)	CO Emissions (tons/year)
City Total	94.7	618	23530
CBD	96.1	31	1200

DIESEL

	Emission Factor (gm CO/mi.)	VMT (10^3 mi./day)	CO Emissions (tons/year)
City Total	20.4	84	690
CBD	20.4	28	230

The estimates reflect major highway projects due to be under traffic by 1977. These are:

- I-95 (Delaware Expressway). Remaining link throughout City and southerly to Chester.
- I-76 (Vine Street Expressway).
- I-476 (Mid-County Expressway).
- Industrial Expressway-26th Street connector interchange.
- Chester and Delair Bridges.
- I-295. Remaining links throughout region in New Jersey.
- I-76 connection to Ben Franklin Bridge.

The estimates also reflect the reductions expected from the emission controls required to be installed on new vehicles beginning with the 1972 and 1975 model years, adjusted for deterioration as described in 4.2.1. Since there must be compliance with the air quality standard by July 1977, the CO emission rate was adjusted from the year end values shown in the table to mid-year values of tons CO per year total for the City and the CBD. Calculations are shown in Appendix A.

4.3 CONTROL MEASURE SELECTION

4.3.1 Technical Requirements

Table 4-3 summarizes the 1971 and 1977 carbon monoxide emission levels compared with the levels estimated to be needed to achieve compliance with the ambient air quality standard. Mobile source emissions must be reduced about 56% from 1971 levels to achieve the carbon monoxide air quality standard. About 9% of the reduction needs to be achieved with transportation controls. The other 47% is expected to be achieved mainly with Federally mandated new car emission controls plus the benefits of higher average speeds due to programmed highway changes.

4.3.2 Technical Feasibility

Control measures are those actions taken that are expected to result in a reduction in total emissions. Control measures will fall into one of two groups; emission related and VMT reduction. Emission related control measures

Table 4-3. EMISSION REDUCTION REQUIREMENTS, CITY & CBD

	October, 1971	July, 1977	
	Estimated Actual	Estimated Actual Without Transportation Controls(1)	Estimated Actual Required
Citywide			
Ambient air quality 22.5 mg/m^3 CO, 8-hour average	22.5	-	10
Mobile source emission ton/yr. CO	302000	159000	133000
% Reduction	-	47	56
CBD			
Mobile source emission, ton/yr. CO	25500	10000	11200
% Reduction	-	61	56

(1) Reductions reflect new car emission controls scheduled to be in service and major highway changes programmed for completion.

achieve reductions in emissions per vehicle mile by the use of emission control devices, inspection/maintenance requirements, alternative energy sources such as gaseous fuels and electric power, and speed control. The other group of control measures achieve reduction by reducing the vehicle miles traveled (VMT).

EPA regulations require that vehicles be equipped with emission controls that maintain emissions below specified limits. Table 4-3 shows emission estimates that indicate reductions by 1977 of 47 percent overall for the City and 61 percent for the CBD through utilization of emission controls and through the effects of programmed highway and bridge construction. Emission controls are the major component of this estimated reduction. The estimated reduction from emission controls are based on minimal low mileage test data (4000 mile) and for only pre-1972 models[7]. Reductions for later year models are estimated. A deterioration factor is applied to account for the aging or deterioration of the control devices beyond the low mileage test period and estimates. The estimated reductions should not be relied on unequivocally until confirmed by additional test data.

Other emission related control measures were considered for inclusion in the transportation control strategy. Emission related control measures produce a decrease in the quantity of pollutants emitted per mile of vehicle travel. They have the advantage over VMT reduction methods of achieving pollutant reductions without requiring control measures, which may have to include severe restraints, for reducing the VMT. However, technical feasibility or cost effective deterrents to emission related control measures such as inspection/maintenance, gaseous fuels and electrification need to be overcome. Speed increases fall into the emission related groups because emissions of CO and hydrocarbons are reduced as speed is increased.

VMT reduction control measures may be considered as either alternatives or in addition to the emission related control measures. VMT

reduction is achieved by either reducing the travel demand (fewer total trips within the region) or to divert trips to less polluting forms of transit. Socio-economic problems generated by the first solution tend to dominate the obstacles to this group of control measures. The major obstacles to the diversion of riders to less polluting forms of transit are public acceptance of alternative transit modes and the high capital and operating costs of these systems.

4.3.3 Institutional Considerations

Any candidate control measure should be considered in relation to the economic, political, and social problems likely to be encountered upon its implementation. The various obstacles to the control measures considered for Philadelphia have been documented in subsection 4.4.9. Cost effectiveness is also discussed for those control measures where cost estimates are available in subsection 4.4.8.

4.3.4 Control Measures Considered

Several control measures were considered which were finally rejected as infeasible. The rationale for their rejection are discussed in this subsection.

Inspection/Maintenance. Idle Mode Test. This test measures the emissions during an idling cycle. The test is performed rapidly and test equipment is less expensive than for multi-cycle emission tests. However, the test provides only limited diagnostic information for performing the required maintenance if needed.

Inspection/Maintenance. Mandatory Tuneup. This control measure requires that complete tuneups be performed on all vehicles regardless of vehicle condition. Limited test data indicates that rejection of more than about 40% of the tested vehicles does not result in substantially greater emission reductions [8]. It was therefore concluded that mandatory

[8] Joel Horowitz, The Effectiveness and Cost of Inspection & Maintenance for Reducing Automobile Emissions

tuneup would not be a cost effective control strategy.

Gaseous Fuels. Emission rates expected from 1975 model years and beyond compare favorably with those rates from gaseous fueled vehicles. Philadelphia's taxi fleet would have only about 400 pre-1975 cabs on the streets by 1977 as candidates for possible conversion, an insignificant impact on the air quality. No other sizeable fleets were found for potential conversion.

Car Pools. The gradual population movement away from the center city has resulted in reduced population densities and discouraged car pools as a transit mode. Until this trend is reversed, voluntary car pooling is not an attractive alternative for most commuters.

Economic Penalties. Economic penalties would not likely impact high income levels to the degree they would impact low income groups.

4.4 CONTROL MEASURES AND STRATEGY FOR PHILADELPHIA

4.4.1 Strategy Goal

It is estimated that to meet the ambient air quality standard for CO by 1977 that a 9% reduction from 1971 levels in mobile source emissions is required beyond that expected to be achieved by new car emission controls and programmed highway changes. This equates to a total mass reduction of about 26,000 tons CO per year. The control measures described below are alternative or coexisting measures for attaining this stated level of reduction.

4.4.2 General Considerations

The estimated emissions reductions from these control measures indicate that emission related control measures alone will not achieve compliance with the ambient air quality standards by 1977. VMT reduction control measures alone can be implemented that would achieve compliance but only with massive funding for public transportation and very severe driver restraints. It is not likely that such control strategies are implementable. It is possible that a combination of emission related and VMT reduction control measures will achieve compliance with somewhat less transit funding and driver restraints. Following a description of the control measures and their effects, various of these combinations will be compared.

4.4.3 Emission Related Measures

4.4.3.1 Inspection/Maintenance (Loaded Emission Test Without Retrofit)

Estimated emission reduction is 6 percent City total and 5 percent for the CBD. EPA considers this approach to be the most generally applicable of the several inspection/maintenance alternatives for in-use vehicle emissions control. Therefore, their guidelines require that data and analyses supporting the emissions reductions claimed for alternative approaches must be submitted with the transprotation control plan. This control measure has thus been included although other inspection/maintenance approaches can be better integrated with Pennsylvania's established safety inspection program.

Annual reduction is 17,050 tons per year total for the City and 1,300 tons per year for the CBD. No reduction was considered for heavy duty and diesel vehicles.

The specific emission test considered is the Key Mode test which requires measurement of emissions during cruise, deceleration and idle modes of an acceleration-cruise-deceleration-idle cycle.[15] Average annual reductions in CO are estimated to be 10 percent from a tuned base, 20 percent reduction to no reduction after one year[17] Act No. 154[22] of Pennsylvania law is the authority for establising an inspection/maintenance program. The law requires inspections every six months. Therefore, estimated average annual reduction would be 15 percent and was the value used to determine the estimated emission reduction. Inspection of pre-1968 vehicles is not considered because Act No. 154 requires inspection only of vehicles equipped with emission controls. If all vehicles were to be put under the inspection program, additional reductions would be possible.

Reduction estimates are effected by adjusting the 1977 emission factor of the affected model years downward by 15 percent.

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(15) "Control Strategies for in-Use Vehicles," Preliminary Draft, Environmental Protection Agency, August 9, 1972.

(17) Federal Register, Title 40, Preliminary Draft, Requirements for Preparation Adoption, and Submittal of Implementation Plans, Transportation Control Measures, October 12, 1972.

(22) Act No. 154, Approved June 16, 1972, Effective September 15, 1972.

4.4.3.2 Inspection/Maintenance (Engine Parameter Diagnosis Without Retrofit)

Estimated emissions reduction is 4 percent City total and 3 percent for the CBD. This approach requires that maintenance be performed on the vehicle if needed after a periodic diagnostic test that prescribes the maintenance required. Annual reduction is 11,480 tons per year total for the City and 700 tons per year for the CBD. Parameters inspections might include RPM, timing, spark plugs, ignition wires, distributor, air cleaner, PCV valve, carburetor adjustment, air injection system, and emission controls.

Average annual reductions in CO are estimated to be about 7 percent from a tuned base, 13 percent reduction to no reduction after one year [15]. An average reduction of about 10 percent was thus assumed applicable for a six-month inspection program. The estimates reflect empirical studies using test fleets representative of the California vehicle population using 1972 Federal Certification Test Procedures. Differences from these estimates may be expected when applied to the vehicle population in the Philadelphia area. A major weakness of engine parameter inspection/maintenance is the lack of an integral surveillance procedure for evaluating effectiveness. Because of this and because of the statistical uncertainties in the reduction estimates, an adjunct emission test program needs to be included in surveillance procedures. This might be accomplished through statistical sampling of the vehicles subject to inspection in only those regions of the State that must implement transportation control strategies.

4.4.3.3 Inspection/Maintenance (Engine Parameter Diagnosis With Retrofit, Air Bleed to Intake Manifold).

Estimated emissions reduction is 4 percent City total and 3 percent for the CBD. Act No. 154 stipulates inspection of controlled vehicles only. To avoid the political and administrative difficulties which may evolve from requiring inspection of only one class of vehicles, the State may wish to require the retrofitting of all precontrolled vehicles, thus having controls on all State licensed light duty vehicles. Air bleed to intake manifold was chosen from several retrofitting methods because it appears to be the most cost effective. Significantly higher reductions are projected for 1977 with retrofit than without retrofit but it must be

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(15) "Control Strategies for In-Use Vehicles."

realized that the same effect will occur without retrofit in later years as pre-controlled vehicles gradually disappear from the streets. Annual reduction is 13,450 tons CO per year total for the City and 860 tons CO per year for the CBD.

Emissions reduction estimates differ from estimates of reductions from engine parameter diagnosis without retrofit by the application of the same 10 percent reduction to pre-1968 light duty vehicles as to post-1967 vehicles. Test data indicate significantly higher reductions due to air bleed to intake maniforld retrofit but full credit has not been taken because the test data were limited.

4.4.3.4 Curbside Parking and Loading Regulations

The TOPICS traffic control program scheduled to be implemented by 1977 will not be effective in improving traffic flow in the CBD unless existing parking and loading regulations are enforced. Benefits can thus be derived only by strict enforcement of existing regulations in conjunction with the TOPICS program. Estimated reductions due to the TOPICS program are less than 1 percent total for the City and 3 percent for the CBD. City total emissions reduction are 3,490 tons per year and CBD emissions reduction are 810 tons per year. TOPICS effects will come from an increase in average speed from 18.8 m.p.h. without TOPICS to 22.0 m.p.h. with TOPICS improvements. This results in a reduction in average emission rates. Speed projections were determined as described in Appendix B.

4.4.3.5 Electrification

Estimated emissions reduction is less than 1 percent if all motor buses are electrified. Estimated reductions are based on a daily VMT reduction of 84,000 miles average. Annual tonnage reductions are 688 tons CO City total and 234 tons CO for the CBD.

4.4.4 VMT Reduction Measures

The control measures presented above all produce a decrease in the quantity of pollutants emitted per mile of vehicle travel. The alternative, in terms of achieving an allowable emission level, is to either reduce the travel demand (fewer total trips within the region) or to divert trips to

less polluting forms of transit. The latter, diversion of trips, will be considered first followed by alternative control measures to restrain total trips.

4.4.4.1 Increase Mass Transportation Ridership

It has not been possible within the time frame and scope of this study to project increased transit usage specifically associated with each measure defined below. Additionally, each of the measures has social and economic implications quite apart from air pollution considerations. It is therefore recommended that detailed planning consideration be given to all aspects of any transit improvement measure prior to its implementation.

Emissions reductions are estimated for several levels of increased transit ridership due to diversion as follows:

CITY TOTAL

Increase in Ridership (percent)	Reduction in Emissions (percent)	Tons CO/Year
1	0.2	460
5	1.0	3010
10	2.0	5840
20	4.0	11960

CBD

Increase in Ridership (percent)	Reduction in Emissions (percent)	Tons CO/Year
1	0.2	60
5	1.0	260
10	2.1	540
20	4.4	1120

Calculations are detailed in Appendix-B. The analysis considers that diversion is proportional for all trip lengths and therefore gives some bias toward the shorter trip length. Accordingly the results are estimated minimum effects. Greater effects on emissions are obtained by considering

only work trips which are somewhat longer overall. The difference in effects also suggests that emphasis be placed on implementing those mass transportation control measures which focus on diversion to mass transit of the longer trip types. The 1970 census[21] provides work trip data by mode and gives an indication of origin-destination patterns within Philadelphia and its Standard Metropolitan Statistical Area (SMSA). Effects of various levels of diversions of these work trips was estimated, results as follows:

CITY TOTAL

Increase in Ridership (percent)	Reduction in Emissions (percent)	Tons CO/Year
1	0.3	1060
5	2.0	5100
10	3.0	10080
20	7.0	20100

Mass transportation improvements programmed for completion by 1977 are listed in Appendix A. Additional control measures which have the potential for increasing ridership are as follows:

- Center City tunnel connection of suburban rail stations
- Additional park and ride facilities
- Capacity increase
- Shorter headways
- Security force to eliminate crime in stations and transit cars
- Rider amenities (appearance, lighting, better seating, station upgrading)
- Unified fare system
- Work staggering in CBD
- Circumferential transit
- Commuter rail and subway extensions

Center City Tunnel Connection

The tunnel will connect Penn Central Suburban Station and Reading

Terminal, providing pass through commuter train service,additional trips without intermodal transfer, and better use of capacity. Completion is possible by 1976.

Additional Park and Ride Facilities

Existing facilities are a success and more are planned.

Capacity Increases

This control measure is to assure that equipment is available to accomodate projected ridership increases.

Shorter Headways

Shorter headways also serve to increase capacity as well as being a potential time savings incentive for increased ridership.

Rider Amenities (appearance, lighting, better seating, station upgrading)

Station appearance and lighting is being improved on the subways. Effects on ridership are difficult to project.

Security Force

Some modes are presently being patrolled by man/dog teams. The hoped-for effect is a sense of security provided by the presence of crime deterrents whether it be the physical presence of guards or remote camera surveillance.

Unified Fare System

Plans to eliminate some of these inequalities should be accelerated to make intermodal transfer more attractive.

Work Staggering in the CBD

Successful work staggering would increase capacity an estimated 15 percent by stretching the present peak=hour to two hours. LIttle or no capital funds are required.

Circumferential Transit

Better transit to outlying work areas should be provided by this means. SEPTA plans for circumferential transit across North Philadelphia might be achieved by 1977 with immediate funding.

Commuter Rail and Subway Extensions

Lines should be extended to serve the expanding suburbs.

4.4.4.2 Restraints

Estimated emissions reduction is 2 percent (6130 ton/year) per 100,000 trips assuming an average trip length of 5 miles. Restraints will be difficult to implement and only two are considered as feasible at this time:

- Congestion Pass - Only those vehicles with demonstrated need to be in congested areas may enter
- Parking Space Control - Growth in parking spaces is regulated to conform with allowable growth factors

It can be seen that the Congestion Pass is likely to be the more effective of the two alternatives since there are only about 40,000 off-street parking spaces in the CBD. Parking Space Control is seen as a useful tool for the control of VMT growth discussed in the following subsection.

4.4.5 VMT Controls

If emission controls fail to reduce CO levels in the ambient air to the level of the standard, the major criteria for further reductions is the control of vehicular miles traveled (VMT). The responsible planning agencies need to consider the effect of VMT on pollutant levels and set VMT growth factors for conformance with air quality standards. This concept was well expressed in Air Management Services transportation control plan[23] which said,

> "One of the most serious obstacles to success of this plan is the persistent failure of the responsible transporation planning agencies to adequately weigh the environmental factor in their planning and implementation".

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[23] Control of Vehicular Air Pollution in a Comprehensive Program, November 3, 1972.

The concept of VMT growth is shown on Figure 4-1. The positive slope of the curve represents allowable increases in VMT growth as 1975 emission controls impact on an increasing percentage of the total vehicle population. Reduced total emissions from the more effective 1975 emission controls allows additional auto trips to be made up to a maximum level of VMT. The implementation of an effective inspection/maintenance program or other emission related control measures would allow the VMT ceiling to be raised proportionate to the emission reductions achieved.

4.4.6 CBD Priority

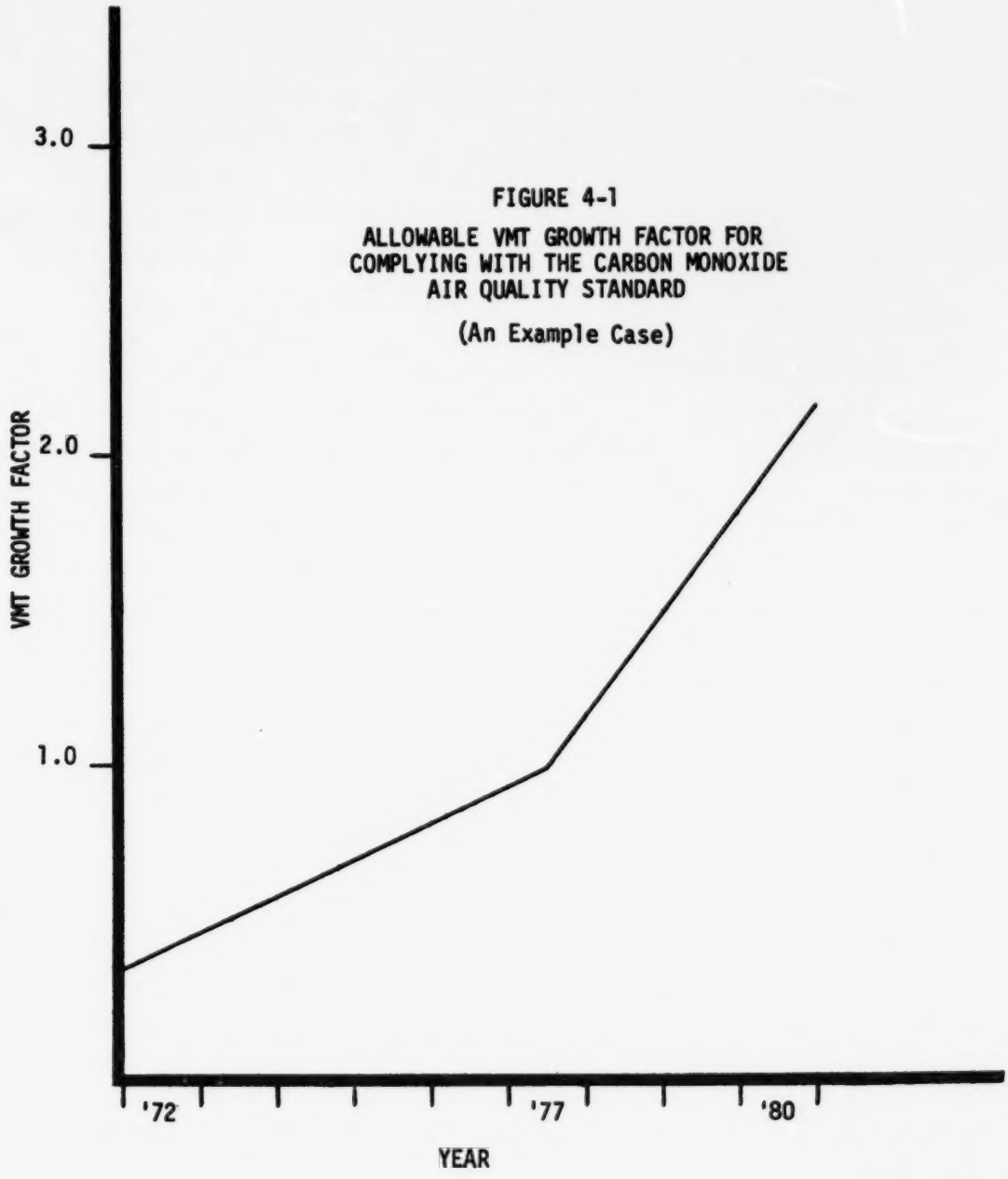
The transportation plan should give priority to those strategies which preferentially control emissions from the CBD. The ratio of emission density in tons per year per square mile,was 4.0 in the CBD to 1 in the rest of Philadelphia during 1971. Projections to 1977 show that the emissions density will be reduced to 2.7 in the CBD to 1 in the rest of Philadelphia, a significant reduction but still showing that emissions are concentrated in the CBD to a degree requiring priority attention. The areas assumed for determining emission densities were 2.9 square miles for CBD and 124.1 square miles for the rest of the City. Since the CBD is the only portion of the City for which VMT was available, there may be another congested area where priority attention is needed. Definitive traffic and air quality data in suspect areas or corridors such as those listed in Section 3.1.5 are needed. Some example control measures effecting CBD Priority are as follows:

- Effective traffic controls through curbside parking and loading regulations
- Electrification of motor buses
- Diversion of trips with CBD origin to mass transit
- Restraints

FIGURE 4-1

ALLOWABLE VMT GROWTH FACTOR FOR COMPLYING WITH THE CARBON MONOXIDE AIR QUALITY STANDARD

(An Example Case)



4.4.7 Control Measure Combinations

The cumulative effects of selected combinations of control measures were compared in relation to VMT reduction required to meet the air quality standard. A transportation control strategy is required to reduce mobile source emissions by 26,000 ton CO/year from a base level of about 159,000 ton/year to 133,000 ton/year. Assuming that the TOPICS program is effective, a 1% (4000 ton/years') reduction is achieved. Reduction effected by inspection/maintenance (engine parameter without retrofit) would add another 10,000 ton/year reduction for a cumulative reduction of 5% (14,000 ton/year). With no other emission related control measures implemented, a 10% reduction of VMT is required from 1977 base level VMT to achieve the additional 4% (12,000 ton/year) reduction needed to reach the 133,000 ton/year level. Turning now to one other combination; if inspection maintenance is not effective or not implemented and assuming the same reduction due to the TOPICS program, a 17% reduction in VMT is needed to reach the same 133,000 ton/year level.

4.4.8 Cost Effectiveness

4.4.8.1 Limitations

Limitations of the data base for defining cost effectiveness is described in subsections 3.3 and 3.4. Cost effectiveness is defined in broad terms as the maximum benefit achieved for the lowest unit cost. For the purposes of this study, cost effectiveness is the reciprocal of the total mobile source emission reduction achieved per unit of cost. Limited data on inspection/maintenance control measures was available to estimate the cost effectiveness for comparison of the alternative inspection/maintenance procedures. In the case of the VMT reduction control measures, no data base was available for relating the cost of mass transportation improvements to reductions in VMT. The missing link in the data is the individual response of the auto driver to the attractiveness of the improvements in mass transit. Recommendations are made in the following section for developing this information. Restraints can probably be implemented at comparatively nominal costs but, to be implementable, alternative modes of travel need to be provided. As a consequence restraints must be tied to mass transportation costs.

Analysis of inspection/maintenance cost effectiveness does not adjust for routine maintenance that the vehicle owner would do anyway. Thus, total maintenance costs are probably overstated substantially but the order of preference ranking would be the same in any case.

4.4.8.2 Inspection/Maintenance

The three inspection/maintenance alternatives; loaded emission test without retrofit, engine parameter diagnosis without retrofit, and engine parameter diagnosis with retrofit were compared. Only the costs and effects accruing to the Philadelphia region were considered. The following assumptions were made:

- Statewide inspection on a six month cycle
- 40% rejection rate
- Uninspected cars driving in region are negligible
- $ 30 average maintenance cost
- $ 38 average annual cost of retrofit (air bleed to intake manifold)

The projected vehicle base was determined from 1960 & 1970 auto registrations in Pennsylvania's five county portion of the region projected linearly to 1977. A base of 1,400,000 vehicles was estimated by these means. Franchised stations in the region were assumed to be in the same proportion to vehicle population of the region as the statewide station to vehicle population ratio. A 1977 base of 3300 franchised stations was projected.

The inspection and maintenance costs were based on studies reported by EPA in a paper titled The Effectivness and Cost of Inspection and Maintenance for Reducing Automobile Emissions.[8] Investment costs for the loaded test are an order of magnitude estimate of the installation and equipment cost of $ 100,000 per inspection lane, 5-year depreciation[19]. Regional requirements were estimated to be 72 lanes.

Table 4 gives the estimated costs for each control measure. Cost effectiveness values in dollars per ton of CO reduced per year are as follows:

Loaded test without retrofit	$ 3100
Engine parameter without retrofit	$ 5000
Engine parameter with retrofit	$ 5200

Table 4-4. ESTIMATED INSPECTION/MAINTENANCE COST

	Investment	Cost/Vehicle Inspection	Maintenance	Total
Loaded Test Without Retrofit	1.00	3.20	33.60	37.80
Engine Parameter without Retrofit	(1)	16.80	24.00	40.80
Engine Parameter with Retrofit	(1)	16.80	24.00	40.80

		Total Annual Cost 700		
Loaded Test without Retrofit	1400	4,480	47040	52,920
Engine Parameter without Retrofit	----	23,520	33600	57,120
Engine Parameter with Retrofit	----	23,520	33600	57,120
Retrofit				12,236
				69,356

(1) Negligible

4.4.8.3 Increase Mass Transportation Ridership

Without projections for the modal shifts achieved by mass transit control measures, cost effectivenss is indeterminable. Several of the public transportation measures require heavy capital investment. Rule of thumb costs [20] associated with the various elements of the selected control measures are listed as follows:

Center City tunnel connection

$206,000,000 capital investment

Additional park and ride facilities

$ 1500 per space

Capacity increases

$ 420,000 capital for rail car
$ 300,000 capital for subway car
$ 42,000 capital for motor bus
$3,000,000 capital for enlarging a station

Security force

$ 18,000 for one man/dog team annual operating cost

Rider amenities

$ 400,000 - 700,000 for upgrading one station

Commuter rail and subway extensions

$20,000,000 per mile

Inspection of these figures show that the initial costs alone of a comprehensive plan for mass transportation improvements is substantial. Funding of mass transportation is a major obstacle and a high priority item of the transportation control plan.

4.4.9 Obstacles to Implementation

Documentation of obstacles was accomplished by literature review, interview of state and local government officials, of citizen and commercial groups, of the DVRPC, and written comments on preliminary transportation plan proposals by many of the same organizations. Appendix C includes a bibliography and a list of contacts. Extensive use of the Six Cities Report[5] was made.

For each alternative control measure, obstacles are documented by category, as follows:

- Technical
- Economic
- Institutional
- Political
- Legal
- Time Constraint
- Negative Effect

INSPECTION/MAINTENANCE - GENERAL

Technical Obstacles

The inspection test must pass or fail cars in a manner similar to Federal Test Procedures.[16] Without this validation, there is no assurance that the use of the inspection test as a basis for requiring maintenance provides any real contribution to the improvement in air quality. In the absence of such confidence, the State may not be eligible for Federal financial support of the inspection program as authorized by the Clean Air Act.[7]

The composition and physical properties of fuels vary with the season and with the grade of fuel. These variables, interacting with temperature and humidity changes, could under some circumstances accentuate air-fuel ratio changes well beyond normal.[9] With air-fuel ratio changes, changes in CO emission levels can be expected. Thus, failure rates may

vary with the seasons and might overtax repair facilities and be a cause for considerable complaint by vehicle owners.

Vehicle performance parameters other than low pollutant emissions need to be achieved. Otherwise, owners may be tempted to tamper with engine adjustments and emission controls despite severe penalties written into the State law for such acts.

Institutional Obstacles

One public opinion survey reported by Northrup Corp [1] showed considerable apprehension about the potential abuses by private garages.

Service garages tend to make unnecessary repairs [15].

Convenience of inspection station location can be a factor, as indicated from the public opinion survey reported by Northrup[1]. Excessive trip lengths required to visit inspection stations will also partially offset the effect of the inspection/maintenance on total emission reduction.

Political Obstacles

Opposition to a statewide system from vehicle owners in the non-urban areas with relatively clean air may be substantial.

INSPECTION/MAINTENANCE - LOADED TEST

Technical Obstacles

The Clean Air Act requires that federally-funded programs be demonstrated to be effective. Demonstrating effectiveness entails measuring the emission reductions achieved. The effectiveness requirement may cause too high a rejection rate which may be at variance with the capacity of repair and retest facilities and may cause adverse public reaction to high rejection rates.

The loaded test does not specifically define which engine parameters need correction [15].

Economic Obstacles

Large capital outlays are required for acquisition of expensive equipment.

One study[2] concluded that the key mode test would require 142 classroom hours of training.

Legal Obstacles

The loaded emission test is not easily adaptable for use by State franchized inspection stations. State law requires that inspection be done by these stations.

INSPECTION/MAINTENANCE - ENGINE PARAMETER DIAGNOSIS

Technical Obstacles

Mechanics have a tendency to disregard the diagnostic information supplied [15].

The engine parameter test and required maintenance must be tailored to relate to the specific engine and emission control system [17].

Legal Obstacles

Any control measure incorporating in-use vehicle emission control approaches must provide for field verification of the emissions actually achieved, as required by 40 CFR Section 51.19d of EPA regulation [17].

RETROFIT

Technical Obstacles

The adverse effects of retrofit systems may include rough operation at low speeds, rough idling speed, and an increase in creep speed.

Installation of retrofit requires the adjustment of several engine parameters. Emission reductions in any degree of magnitude over and above that achieved from maintenance alone is questionable.

The effectiveness will decrease in future years as pre-controlled vehicles become a smaller fraction of the vehicle population [15].

Political Obstacles

Organized opposition to retrofitting may come from Community Legal Services and from labor unions.

Legal Obstacles

Inspection of retrofitted vehicles would require an amendment to Pennsylvania Law.

CURBSIDE PARKING & LOADING REGULATIONS - IMPROVED TRAFFIC FLOW

Negative Effects Obstacles

Increased travel speeds (and therefore shorter triptimes) eventually generate longer trips. Also, it is conceivable that traffic flow improvements by attracting more traffic could increase peak hour traffic volumes on the existing street systems.

CURBSIDE PARKING & LOADING REGULATIONS - ENFORCEMENT

Technical Obstacles

In a given traffic lane, removal of parked vehicles must be total for use of that lane by traffic.

Institutional Obstacles

Building maintenance service vehicles plus emergency parking require temporary parking provisions which are now only provided by on-street space utilization.

Political Obstacles

City employees and city vehicles are frequent violators of parking restrictions. Illegal parking by public vehicles suggests the need for additional off-street parking space for these vehicles.

CBD merchants claim there is no viable alternative to curbside loading during daylight hours and cite union objections to nighttime loading operations. Nighttime loading would not be feasible for certain "Mom and Dad" type enterprizes.

ELECTRIFICATION

Economic Obstacles

The Southeastern Pennsylvania Transportation Authority (SEPTA) has ordered five battery powered buses on an experimental basis. However, since SEPTA also plans to replace 900 of its 1500 motor buses with diesel operated vehicles, it is anticipated that a long time will elapse before these new vehicles could even be considered for replacement.

INCREASE MASS TRANSPORTATION RIDERSHIP - GENERAL

Technical Obstacles

Low-density land-use patterns with their disperse origins and destinations simply make major segments of the population difficult to accommodate by mass transit.

Economic Obstacles

The Urban Mass Transportation Assistance Act of 1970 commits the Federal Government to obligate $10 billion by 1982 for capital grants to improve transit systems. In the Six Cities Study[5] it was estimated that if the Federal Government were to contribute two-thirds of the capital investment costs needed by the six cities (New York, Chicago, Washington, Los Angeles, Denver, San Francisco) over 90 percent of the total $10 billion available for the entire country would be expended for just these six

cities. Vigorous competition between urban areas for these funds may be expected.

There is little or no prospect of attracting motorists to public transport by minor improvements. Major improvements have a high price tag.

PARK & RIDE FACILITIES

Technical Obstacles

There is a lack of available space near some of the stations within the city.

Institutional Obstacles

Such a program probably would do little by itself to encourage more shoppers to use transit today. Today, most downtown sales are made to "captive" office workers at noon and after work. The exception, of course, is on Saturday and during certain times of the year such as Christmas. It is felt that without major improvements throughout the transit system, suburban shoppers will continue to drive to outlying centers despite the provision of transit parking facilities.

CAPACITY INCREASES/SHORTER HEADWAYS

Technical Obstacles

Public opposition to increasing the number of motor buses, particularly diesel, may be substantial because of unpleasant sensory effects (noise, smoke, odor) from the exhausts.

Access - egress is slowed and thus trains tend to bunch at Market - Frankford terminals (69th Street and Bridge - Pratt Street terminals).

At the 69th street terminal, the existing switching tunnel beyond the station is not long enough to enable an 8-car train to switch tracks for its return run. The elimination of this problem will require major new construction which may not be completed by 1977.

RIDER AMENITIES (APPEARANCE, LIGHTING, BETTER SEATING, STATION UPGRADING)

Economic Obstacles

Transit station amenities currently are being improved especially in the CBD, and in the Model Cities Area. This will help to improve the image of public transit but without a complete overhaul of the system (new air conditioned cars, improvements in convenience and fare structure, and an aggressive marketing program), these improvements probably will have little effect on overall ridership. An old and long neglected transit system cannot be made to rival the convenience and attractiveness of the private auto without a massive expenditure of public funds. Even if such authorization were forthcoming, it is doubtful that very much could be achieved in the relatively short period prior to 1977.

UNIFIED FARE SYSTEM

Time Constraint Obstacles

SEPTA expects progress on this by 1977 on their system but neither transit authority (SEPTA or PATCO) see any hope of unification between the systems by 1977.

WORK STAGGERING

Technical Obstacles

The scheduling of connecting transit modes will be more difficult.

Economic Obstacles

If a firm's schedule differs from that of its suppliers and/or customers, economic activity is precluded during portions of the day. Also, additional expense may be incurred for lighting, elevator operation, etc.

Additional labor costs will accrue to transit lines due to stretching of peak hours.

Institutional Obstacles

Work schedule changes may disrupt normal activities any of which could be a viable obstacle for the individual, such as:

- Departure time to and from work
- Portions of the day spent home
- Social and recreational activities
- Scheduling of personal business

Negative Effect Obstacles

It is possible for work staggering to reduce mass transportation ridership and increase VMT if transit schedules become less convenient, and driving and parking is less congested at new arrival and departure hours.(12)

Informal work staggering may already be in effect to a degree due to early or late arrivals to capture choice parking spaces, avoid traffic congestion, etc.

COMMUTER RAIL & SUBWAY EXTENSIONS

Technical Obstacles

Electric powered subway and commuter rail lines lack flexibility in that they are not easily or economically shifted with shifts in population densities and origin - destination requirements of the population.(18)

Because of high labor costs, track and catenary maintenance tends to be the "program" type under which a section of line goes unmaintained for extended periods. When maintenance is done, it is with a highly mechanized maintenance crew which may take a section completely out of service during off-peak hours. Service disruptions then occur.(11)

The railroad commuter market is not stable but rather fluctuates over relatively short time periods (11).

Economic Obstacles

To maintain the same level of service, extensions require additional transit or rail cars.

Political Obstacles

Opposition to a specific project (the Northeast extension) by Northeast neighborhoods has been strong.

Time Constraint Obstacles

These control measures probably will not occur until after 1977 [13].

RESTRAINTS - GENERAL

Restraints by themselves are not effective control measures in terms of economic impact and social well being. To maintain the economic vitality of the City, it is necessary to provide alternative means of transportation for those being restrained.

RESTRAINTS - CONGESTION PASS

Technical Obstacles

Through traffic must be rerouted from the areas where restraints are applied. Provision needs to be made for attractive and convenient bypass routes.

Political Obstacles

It will be very difficult to administer, and impossible to administer fairly [14]. Unless vehicles are physically restrained from entering congested areas by gates at entrance points, an elaborate windshield sticker system would have to be devised and enforced by the City. This would be possible under existing State law, however, it would require City Council action.

Legal Obstacles

Court challenges could ensue from those who claim the value of their property had been reduced by preventing vehicular access without due process of law.

PARKING SPACE CONTROL

Institutional Obstables

Public action to restrict the supply of space may afford excessive profits for parking operators if market - set rates are allowed.

Political Obstacles

The City of Philadelphia has the authority through zoning to restrict the construction of new parking facilities anywhere within the city limits. It must, however, hold public hearings prior to such action. The major objection to this measure is that it may hurt existing businesses and/or discourage new firms from locating in the controlled areas. If firms were to be located elsewhere in the Philadelphia area, especially in the suburbs, property owners in the controlled areas might suffer a loss of income and the City, in turn, a loss of tax revenue. In addition, some renewal plans such as Market East depend on the construction of new parking facilities as part of the concept. For these reasons, the city vigorously opposes parking space control.

Negative Effect Obstacles

Shortage of parking space may encourage some commuters to be driven to work by a member of their family with the reverse sequence repeated at the end of the day. The net effect is a doubling in VMT for that work trip. Also, results will depend on effectiveness of on-street parking prohibition enforcement.

VMT Controls

Although it is imperative that responsible planning agencies in the Philadelphia area consider air quality effects in planning transportation

improvements, it does not seem desirable to encourage growth in the suburbs while limiting development in Center City. This may seriously undermine the future social and economic vitality of the Region's core.

A better approach may be to develop a bonus system to encourage Center City developers either to physically connect their projects with rapid transit and/or rail facilities or to provide occupants with some other means of public transportation.

4.4.9.1 Auto Air Pollution Questionnaire

A recent survey of public attitudes relevant to several of the control measures is presented in Appendix D. This limited sample survey of Philadelphia area residents provides some insight into the public response to this control strategy.

5.0 CONTROL STRATEGY IMPLEMENTATION

5.1 AGENCY INVOLVEMENT

Federal.

Environmental Protection Agency. Transportation control plan approval, Pennsylvania DER and Philadelphia AMS resource grants.

Department of Transportation. Grants for mass transit funding.

State

Department of Environmental Resources (DER). Prepare transportation plan, advisory to Penn DOT on inspection/maintenacne program, air quality surveillance.

Department of Transportation. Inspection/maintenance program grants for mass transit funding, data base correction.

Regional

Delaware Valley Regional Planning Commission has the regional transportation planning responsibility.

City

Air Management Services. Air quality surveillance.

Traffic Engineering Division. TOPICS improvements.

Department of Public Property. SEPTA property ownership.

Police Department. Mass transit security, enforcement of parking regulations, restraints, vehicle inspection requirements.

City Planning Commission. Planning function.

5.2 LEGAL AUTHORITY

5.2.1 Inspection/Maintenance

The law would have to be changed to require retrofitting. Pennsylvania legislation is geared to enforcing the provisions of the

federal Clean Air Act of 1970, which deals only with vehicles manufactured 60 days after December 31, 1970 and thereafter.

75 PS 819 and 75 PS 834 of Pennsylvania law specify that the state has the authority to license private firms to carry out motor vehicle emission inspections. This legislation does not provide for the state, itself, to conduct the inspections.

The Clean Air Act of 1970, 42 USC 1857f-5a (b)(2), states that manufacturers must warrantee that vehicles sold after 60 days after December 31, 1970 will meet Federal air quality standards for the particular model year of the vehicle. If the engine is tampered with, either by a dealer or by the eventual owner, the warrantee will no longer hold.

Act 154, section 2 of Pennsylvania law sets a fine of $ 100 for tampering. If the fine is not paid, a prison term of 30 days can be imposed.

5.2.2 Curbside Parking and Loading Regulations

The City Council under Pennsylvania's Motor Vehicle Code of 1959 as amended (in 1963), 75 PS 1103, has the authority to establish any parking and/or loading restrictions that it desires, and there is no limit on the penality imposed to enforce such ordinances. If a state highway is affected, however, permission must be sought from the Secretary of Penn DOT.

The City can contract for towing services, however, the City plans to buy its own tow trucks and provide its own storage facilities.

The local ordinance establishing towing policy must:

(1) Designate storage facilities.

(2) Require bonding of storage lot owners to insure liability.

(3) Set the fee for towing and storage.

Loading regulations can be handled by city ordinance (75 PS 1103).

5.2.3 Mass Transit

The only thing which may prevent the Center City Tunnel from being completed by 1976, is a lack of funds. However, the electorate has approved a bond issue to finance the City's portion of this project.

The Philadelphia Parking Authority has the authority and the funds to build additional transit parking within the City limits. It can also acquire the land by eminent domain. SEPTA has the same power outside the City.

Under the Metropolitan Transportation Authorities Act of 1967 (66PS2004 of Pennsylvania Law) SEPTA has the authority to build transit parking both in Philadelphia and in other jurisdictions within its region.

The City can finance transit improvements either from its general fund or from bond issues approved by the electorate.

In order to give buses priority at intersections or to establish exclusive bus lanes, the City can pass the appropriate ordinance (75PS 1103 of Pennsylvania Law). If such provisions are planned for state highways, however, the Secretary of Penn DOT must approve.

Under the Metropolitan Transportation Authorities Act of 1967 (66PS2001 and 2004 of Pennslyvania Law) SEPTA is empowered to establish whatever fare structure it feels is appropriate. It must, however, hold public hearings prior to establishing or modifying rates.

5.2.4 Restraints

Under 75 PS 1103 the City can regulate the use of any streets under its jurisdiction. This includes restricting or prohibiting use. State approval required for state highways.

The City can levy a parking tax just as it levies other special taxes.

5.2.5 VMT Control

The City is empowered to do as it sees fit with matters of zoning -- subject, of course, to appeal.

5.3 DATA BASE CORRECTION

The limitations of the data base have been thoroughly described in preceding sections. To correct errors likely to be inherent in the data base, an intensified program should begin immediately to update the data base. The elements which need to be updated are as follows:

- Air Quality. Monitoring of air quality for one year beginning with the full operation of the City's citywide monitoring network during 1973. Data is needed to better define the air quality base level for determining reductions required and to validate the air quality diffusion model.
- Detailed Traffic Data. Data is needed for air quality diffusion modeling and to validate or correct VMT growth projection if needed.
- Trip Type, Origin-Destination Data. Data is needed to help define potential ridership increases from mass transportation control measures.
- Vehicle population growth and age distribution. To update projections.

5.4 SURVEILLANCE CHECK POINTS

A timeline diagram is presented on the next page showing the surveillance check points for monitoring progress toward the achievement of the air quality goal by 1977. The need for immediate action on data base update and on funding are paramount. A more positive definition of control requirements and effects depend on the verification of the current air quality leval and on current and projected traffic, trip type and origin destination data. Immediate update of these elements of the data base are needed prior to the selection of specific mass transportation control measures and prior to establishing the extent of traffic restraints required. Funding actions are considered in two categories: Immediate Decision and Deferred Decision. Immediate decision funding are those applications for funding already programmed or which can be programmed without delaying for additional data collection. The mass transportation control measures recommended for immediate decision funding are:

- Center City Tunnel Connection
- Additional Park & Ride Facilities
- Security Force
- Work Staggering in CBD

Deferred decision funding applications require additional data for justification or estimating the emission reduction effect. These are for the mass transportation control measures which generally require large capital investments and/or better defined projected diversion to mass transit. Following update of the data base application for UMTA grants can be filed and transportation bonds voted.

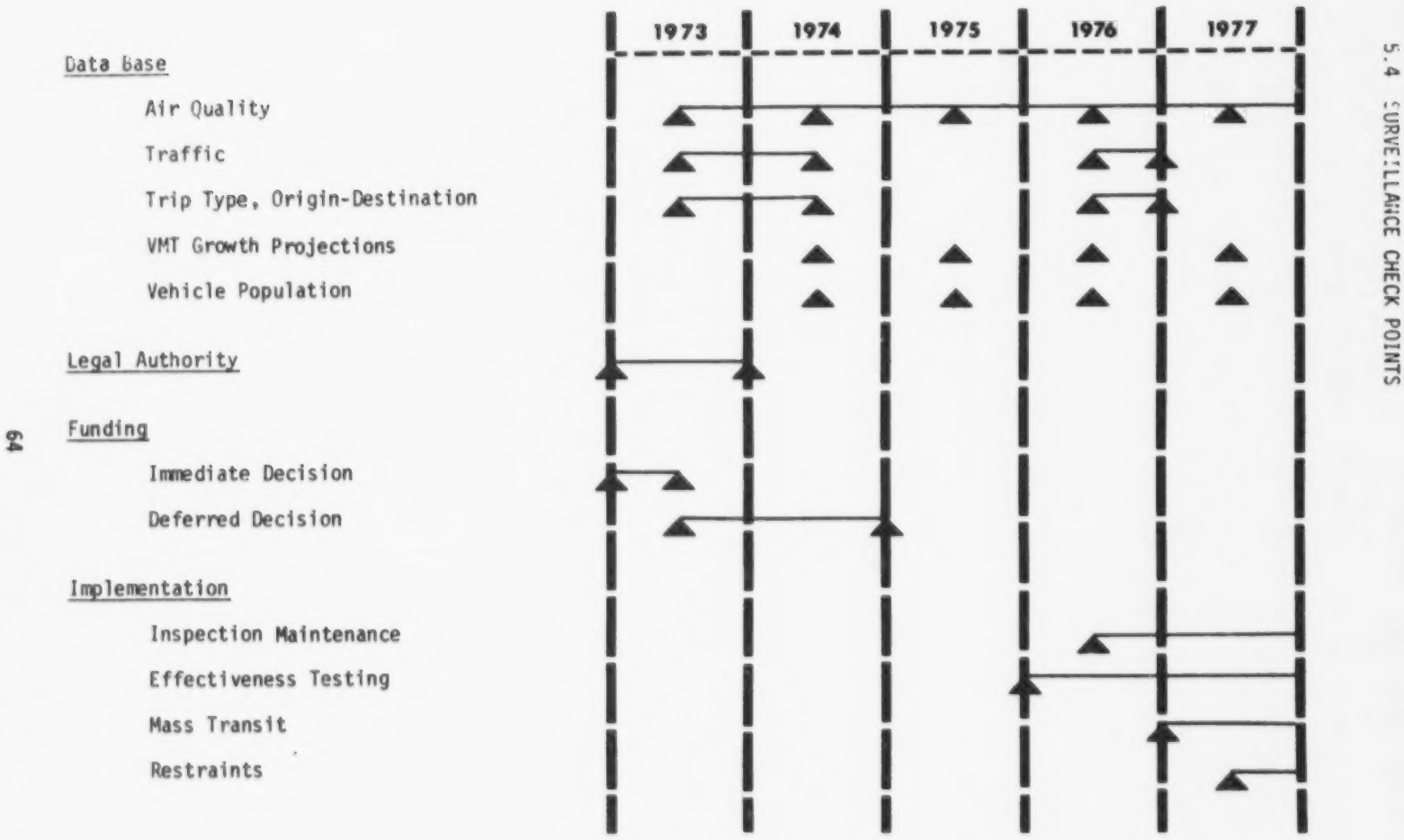

1973
1974
1975
1976
1977
Data Base
Air Quality
Traffic
Trip Type, Origin-Destination
VMT Growth Projections
Vehicle Population
Legal Authority
Funding
Immediate Decision
Deferred Decision
Implementation
Inspection Maintenance
Effectiveness Testing
Mass Transit
Restraints

Figure 5-1

APPENDIX A
AIR QUALITY AND EMISSIONS DATA

THE PROPORTIONAL AIR QUALITY MODEL

A simple proportional model was used to determine the mobile source emissions reduction required to achieve air quality standards. The proportional model is based on the assumption that the reduction in air quality concentration levels is directly proportional to emission reductions. It was also assumed that stationary source emissions of CO were not significant. This is a valid assumption because the larger stationary sources of Philadelphia are far enough away from the receptor site used for concentration measurements to have significant impact.

Calculations are as follows:

$$\text{Fraction Reduction} = R = \frac{Cmax - std}{Cmax - b}$$

Cmax = Annual second highest CO concentration in ambient air = 22.5 mg/m^3 (measured October 16-17, 1971)

std = standard, eight-hour average = 10 mg/m^3

b = background = 0

$$R = \frac{22.5 - 10}{22.5} = 0.56$$

EMISSION FACTOR CALCULATIONS

The equation for calculating emission factors is shown below:[1]

$$e_{np} = \sum_{i=n-12}^{n+1} ci\ di\ mi\ si$$

where,

e_{np} = emission factor in grams per vehicle mile for calendar year n and pollutant p,

c_i = the 1975 Federal test procedure emission rate for pollutant p (grams/mile) for the i^{th} model year, at low mileage

d_i = the controlled vehicle pollutant p emission deterioration factor for the i^{th} model year at calendar year n,

m_i = the weighted annual travel of the i^{th} model year during calendar year n (The determination of this variable involves the use of the vehicle model year distribution),

s_i = the weighted speed adjustment factor for the i^{th} model year vehicles.

c_i is based on a recent study of light duty vehicle exhaust emission rates in six cities. d_i, deterioration factor accounts for the aging or deterioration of emission control devices. m_i, weighted annual mileage is determined as follows,

---

[1] D.S. Kircher and D.P. Armstrong, "An Interim Report on Motor Vehicle Emission Estimation," Environmental Protection Agency, October 1972.

$$mi = \frac{V \times D}{\Sigma V \times D}$$

V = fraction of each modeal year vehicle in use on December 31 of year

D = average miles driven of each model year vehicle

s_i, speed adjustment factor, varies inversely with average route speed. 1975 and later model years are assumed to have a factor of one. For other model years, s_i is greater than one below about 20 m.p.h. and less than one above 20 m.p.h.

TABLE A-1

CALCULATION SHEET - GASOLINE MOTOR VEHICLE EXHAUST EMISSION FACTORS

POLLUTANT CO

VEHICLE WEIGHT CLASS

☐ HDV ☒ LDV

CALENDAR YEAR 1971 (Dec. 31)

METROPOLITAN AREA Philadelphia

MODEL YEAR	c_i	d_i	m_i*	s_i	$c_i d_i m_i s_i$
1959	77	1.00	.0173	1.05	1.40
1960	77	1.00	.0120		.97
1961	77	1.00	.0167		1.35
1962	77	1.00	.0251		2.03
1963	77	1.00	.0401		3.24
1964	77	1.00	.0593		4.79
1965	77	1.00	.0798		6.45
1966	77	1.00	.0992		8.02
1967	77	1.00	.1166		9.43
1968	42	1.47	.1326		8.60
1969	34	1.59	.1478		8.39
1970	31	1.32	.1648		7.08
1971	41	1.18	.0713		3.62
1972	19	1.00	.0174		.35

$\sum c_i d_i m_i s_i = 65.7 \frac{GMS}{MILE}$

*See Reference No. 7, Tables 14 and 20 for sample calculations of Mi. Based on data from Tables B-1 through B-8, Appendix B.

EMISSION REDUCTION ESTIMATES

Total emissions based on estimated reduction in either emissions or VMT are calculated as described in this appendix. The % reduction is calculated as follows:

$$\% \text{ Reduction} = \frac{100(B-R)}{A}$$

A = 1971 emission levels, tons/year
B = 1977 emission levels, tons/year
R = emission level after reduction, tons/year

CALCULATION OF TOTAL EMISSIONS

$$\text{Total Emissions (tons CO/year)} = E = 0.402 \left(e_L \, VMT_L + e_H \, VMT_H = e_D \, VMT_D\right)$$

e = emission factor, gm/mile

VMT = daily vehicles miles traveled x 10^{-3}

Subscrips:

L = light duty vehicle

H = heavy duty vehicle

D = diesel

Result is emission on December 31. To determine emissions on other dates, total emissions were calculated for two consecutive years and interpolated to required date. For example, to determine emissions for July 1977, total emissions were determined for 1966 and for 1977 and midpoint of values found.

EMISSION REDUCTION ESTIMATES

Total emissions based on estimated reduction in either emissions or VMT are calculated as described in this appendix. The % reduction is calculated as follows:

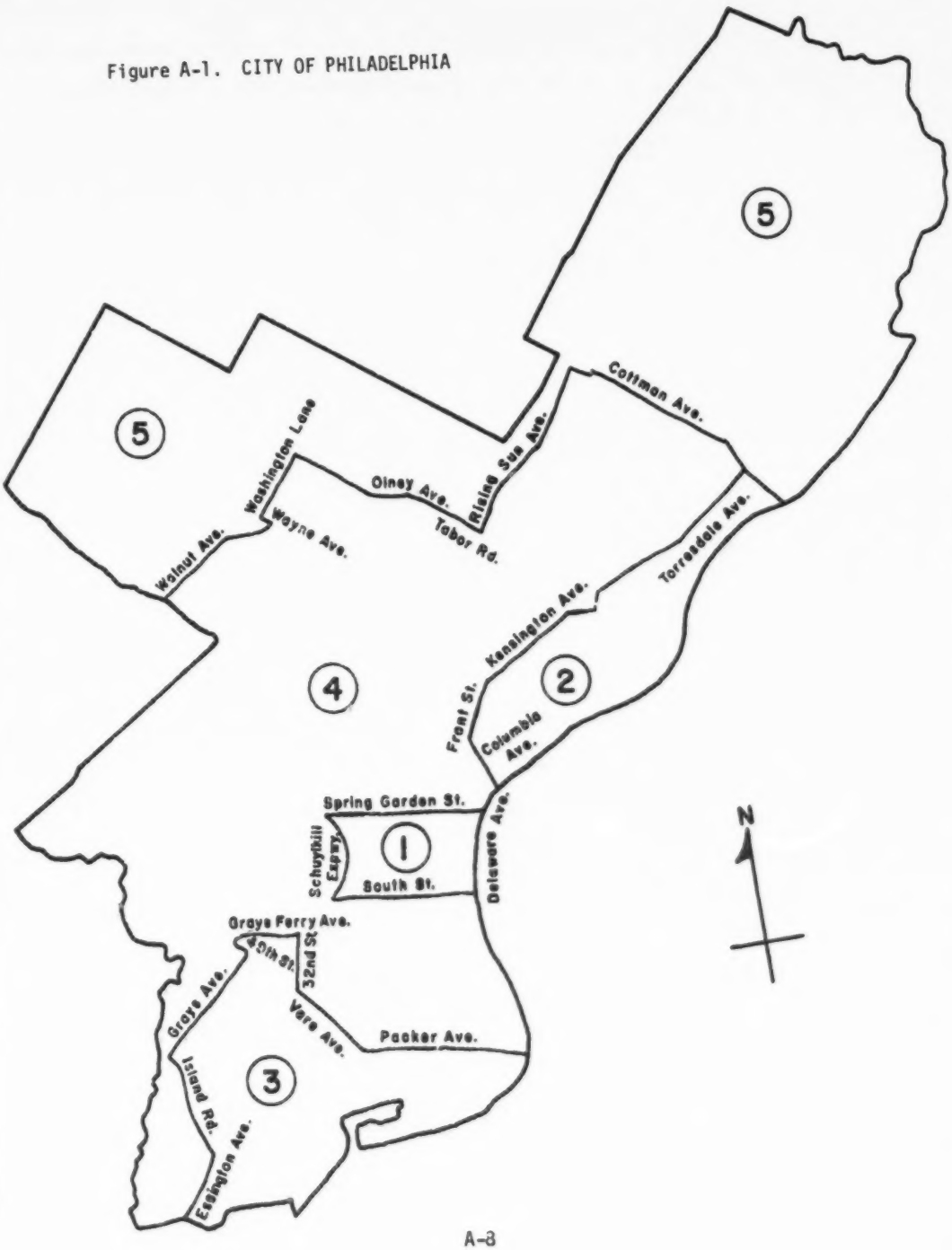
$$\% \text{ Reduction} = \frac{100(B-R)}{A}$$

A = 1971 emission levels, tons/year

B = 1977 emission levels, tons/year

R = emission level after reduction, tons/year

Figure A-1. CITY OF PHILADELPHIA



APPENDIX B
TRANSPORTATION DATA BASE

Table B-1

PHILADELPHIA - CITYWIDE

VEHICLE MILES OF TRAVEL PER DAY--1970
BY LIGHT VEHICLES

Age (Years)	(1) Percent of Total Light Vehicles in Use	(2) Percent of Miles Driven on Annual Basis	(3) Weighted Percent of Daily Travel	Vehicle Miles of Travel by Light Vehicles (Thousands)
0*	3.7	3.8**	1.74	173.4
1	7.7	7.5**	7.13	710.4
2	11.7	11.4	16.48	1,642.1
3	11.5	10.4	14.78	1,472.7
4	11.3	9.5	13.26	1,321.2
5	11.1	8.5	11.66	1,161.8
6	10.3	7.8	9.92	988.4
7	9.1	7.1	7.98	795.1
8	7.5	6.4	5.93	590.9
9	5.5	5.9	4.01	399.5
10	3.7	5.5	2.51	250.1
11	2.5	5.4	1.67	166.4
12	1.8	5.4	1.20	119.6
13+	2.6	5.4	1.73	172.4
Total	100.0	100.0	100.00	9,964.0

$$(3) = \frac{(1) \times (2)}{\Sigma(1 \times 2)}$$

*-Refers to next years model introduced in the Fall.
**-This percent reflects the fact that some vehicles in this age category have not been driven for a full year.

Light Vehicles	Vehicle Miles of Travel	Percent of Total Vehicle Miles of Travel
Autos	9,010,000	85.0
Taxis	318,000	3.0
Light Trucks	636,000	6.0
Total	9,964,000	94.0

Table B-2

PHILADELPHIA - CITYWIDE

VEHICLE MILES OF TRAVEL PER DAY--1970
BY HEAVY VEHICLES

Age (Years)	(1) Percent of Total Heavy Vehicles in Use	(2) Percent of Miles Driven on Annual Basis	(3) Weighted Percent of Daily Travel	Vehicle Miles of Travel by Heavy Vehicles (Thousands)
0*	3.4	3.6**	1.65	10.5
1	7.1	7.6**	7.30	46.4
2	10.0	11.6	15.71	99.9
3	9.5	10.9	13.64	86.8
4	8.8	10.2	12.15	77.3
5	8.0	9.4	10.19	64.8
6	7.0	8.5	8.06	51.3
7	6.2	7.7	6.46	41.1
8	5.3	6.9	4.94	31.4
9	3.8	6.2	3.18	20.2
10	3.7	5.3	2.66	16.9
11	3.3	4.6	2.05	13.0
12	3.2	3.8	1.64	10.4
13+	20.7	3.7	10.37	66.0
Total	100.0	100.0	100.00	636.0

$$(3) = \frac{(1) \times (2)}{\Sigma (1 \times 2)}$$

*-Refers to next years model introduced in the Fall.
**-This percent reflects the fact that some vehicles in this age category have not been driven for a full year.

Heavy Vehicles	Vehicle Miles of Travel	Percent of Total Vehicle Miles of Travel
Medium and Heavy Trucks	477,000	4.5
Buses	159,000	1.5
Total	636,000	6.0

Table B-3

PHILADELPHIA - CENTRAL BUSINESS DISTRICT

VEHICLE MILES OF TRAVEL PER DAY--1970
BY LIGHT VEHICLES

Age (Years)	(1) Percent of Total Light Vehicles in Use	(2) Percent of Miles Driven on Annual Basis	(3) Weighted Percent of Daily Travel	Vehicle Miles of Travel by Light Vehicles (Thousands)
0*	3.7	3.8**	1.74	10.9
1	7.7	7.5**	7.13	44.6
2	11.7	11.4	16.48	103.1
3	11.5	10.4	14.78	92.5
4	11.3	9.5	13.26	83.0
5	11.1	8.5	11.66	72.9
6	10.3	7.8	9.92	62.1
7	9.1	7.1	7.98	49.9
8	7.5	6.4	5.93	37.1
9	5.5	5.9	4.01	25.1
10	3.7	5.5	2.51	15.7
11	2.5	5.4	1.67	10.4
12	1.8	5.4	1.20	7.5
13+	2.6	5.4	1.73	10.8
Total	100.0	100.0	100.00	625.6

$$(3) = \frac{(1) \times (2)}{\Sigma (1 \times 2)}$$

*-Refers to next years model introduced in the Fall.
**-This percent reflects the fact that some vehicles in this age category have not been driven for a full year.

Light Vehicles	Vehicle Miles of Travel	Percent of Total Vehicle Miles of Travel
Autos	544,000	80.0
Taxis	54,400	8.0
Light Trucks	27,200	4.0
Total	625,600	92.0

Table B-4

PHILADELPHIA - CENTRAL BUSINESS DISTRICT

VEHICLE MILES OF TRAVEL PER DAY--1970
BY HEAVY VEHICLES

Age (Years)	(1) Percent of Total Heavy Vehicles in Use	(2) Percent of Miles Driven on Annual Basis	(3) Weighted Percent of Daily Travel	Vehicle Miles of Travel by Heavy Vehicles (Thousands)
0*	3.4	3.6**	1.65	0.9
1	7.1	7.6**	7.30	4.0
2	10.0	11.6	15.71	8.5
3	9.5	10.9	13.64	7.4
4	8.8	10.2	12.15	6.6
5	8.0	9.4	10.19	5.5
6	7.0	8.5	8.06	4.4
7	6.2	7.7	6.46	3.5
8	5.3	6.9	4.94	2.7
9	3.8	6.2	3.18	1.7
10	3.7	5.3	2.66	1.5
11	3.3	4.6	2.05	1.1
12	3.2	3.8	1.64	0.9
13+	20.7	3.7	10.37	5.7
Total	100.0	100.0	100.00	54.4

$$(3) = \frac{(1) \times (2)}{\Sigma (1 \times 2)}$$

*-Refers to next years model introduced in the Fall.
**-This percent reflects the fact that some vehicles in this age category have not been driven for a full year.

Heavy Vehicles	Vehicle Miles of Travel	Percent of Total Vehicle Miles of Travel
Medium and Heavy Trucks	13,600	2.0
Buses	40,800	6.0
Total	54,400	8.0

Table B-5

PHILADELPHIA - CITYWIDE

VEHICLE MILES OF TRAVEL PER DAY--1977
BY LIGHT VEHICLES

Age (Years)	(1) Percent of Total Light Vehicles in Use	(2) Percent of Miles Driven on Annual Basis	(3) Weighted Percent of Daily Travel	Vehicle Miles of Travel by Light Vehicles (Thousands)
0*	3.7	3.8**	1.74	191.4
1	7.7	7.5**	7.13	784.1
2	11.7	11.4	16.48	1,812.5
3	11.5	10.4	14.78	1,625.5
4	11.3	9.5	13.26	1,458.3
5	11.1	8.5	11.66	1,282.4
6	10.3	7.8	9.92	1,091.0
7	9.1	7.1	7.98	877.6
8	7.5	6.4	5.93	652.2
9	5.5	5.9	4.01	441.0
10	3.7	5.5	2.51	276.0
11	2.5	5.4	1.67	183.7
12	1.8	5.4	1.20	132.0
13+	2.6	5.4	1.73	190.3
Total	100.0	100.0	100.00	10,998.0

$$(3) = \frac{(1) \times (2)}{\Sigma(1 \times 2)}$$

*-Refers to next years model introduced in the Fall.
**-This percent reflects the fact that some vehicles in this age category have not been driven for a full year.

Light Vehicles	Vehicle Miles of Travel	Percent of Total Vehicle Miles of Travel
Autos	9,945,000	85.0
Taxis	351,000	3.0
Light Trucks	702,000	6.0
Total	10,998,000	94.0

Table B-6

PHILADELPHIA - CITYWIDE

VEHICLE MILES OF TRAVEL PER DAY--1977
BY HEAVY VEHICLES

Age (Years)	(1) Percent of Total Heavy Vehicles in Use	(2) Percent of Miles Driven on Annual Basis	(3) Weighted Percent of Daily Travel	Vehicle Miles of Travel by Heavy Vehicles (Thousands)
0*	3.4	3.6**	1.65	11.6
1	7.1	7.6**	7.30	51.2
2	10.0	11.6	15.71	110.3
3	9.5	10.9	13.64	95.8
4	8.8	10.2	12.15	85.3
5	8.0	9.4	10.19	71.5
6	7.0	8.5	8.06	56.6
7	6.2	7.7	6.46	45.3
8	5.3	6.9	4.94	34.7
9	3.8	6.2	3.18	22.3
10	3.7	5.3	2.66	18.7
11	3.3	4.6	2.05	14.4
12	3.2	3.8	1.64	11.5
13+	20.7	3.7	10.37	72.8
Total	100.0	100.0	100.00	702.0

$$(3) = \frac{(1) \times (2)}{\Sigma (1 \times 2)}$$

*-Refers to next years model introduced in the Fall.
**-This percent reflects the fact that some vehicles in this age category have not been driven for a full year.

Heavy Vehicles	Vehicle Miles of Travel	Percent of Total Vehicle Miles of Travel
Medium and Heavy Trucks	526,500	4.5
Buses	175,500	1.5
Total	702,000	6.0

Table B-7

PHILADELPHIA - CENTRAL BUSINESS DISTRICT

VEHICLE MILES OF TRAVEL PER DAY--1977
BY LIGHT VEHICLES

Age (Years)	(1) Percent of Total Light Vehicles in Use	(2) Percent of Miles Driven on Annual Basis	(3) Weighted Percent of Daily Travel	Vehicle Miles of Travel by Light Vehicles (Thousands)
0*	3.7	3.8**	1.74	11.8
1	7.7	7.5**	7.13	48.5
2	11.7	11.4	16.48	112.2
3	11.5	10.4	14.78	100.6
4	11.3	9.5	13.26	90.3
5	11.1	8.5	11.66	79.4
6	10.3	7.8	9.92	67.5
7	9.1	7.1	7.98	54.3
8	7.5	6.4	5.93	40.4
9	5.5	5.9	4.01	27.3
10	3.7	5.5	2.51	17.1
11	2.5	5.4	1.67	11.4
12	1.8	5.4	1.20	8.2
13+	2.6	5.4	1.73	11.8
Total	100.0	100.0	100.00	680.8

$$(3) = \frac{(1) \times (2)}{\Sigma (1 \times 2)}$$

*-Refers to next years model introduced in the Fall.
**-This percent reflects the fact that some vehicles in this age category have not been driven for a full year.

Light Vehicles	Vehicle Miles of Travel	Percent of Total Vehicle Miles of Travel
Autos	592,000	80.0
Taxis	59,200	8.0
Light Trucks	29,600	4.0
Total	680,800	92.0

Table B-8

PHILADELPHIA - CENTRAL BUSINESS DISTRICT

VEHICLE MILES OF TRAVEL PER DAY--1977
BY HEAVY VEHICLES

Age (Years)	(1) Percent of Total Heavy Vehicles in Use	(2) Percent of Miles Driven on Annual Basis	(3) Weighted Percent of Daily Travel	Vehicle Miles of Travel by Heavy Vehicles (Thousands)
0*	3.4	3.6**	1.65	1.0
1	7.1	7.6**	7.30	4.3
2	10.0	11.6	15.71	9.3
3	9.5	10.9	13.64	8.1
4	8.8	10.2	12.15	7.2
5	8.0	9.4	10.19	6.0
6	7.0	8.5	8.06	4.8
7	6.2	7.7	6.46	3.8
8	5.3	6.9	4.94	2.9
9	3.8	6.2	3.18	1.9
10	3.7	5.3	2.66	1.6
11	3.3	4.6	2.05	1.2
12	3.2	3.8	1.64	1.0
13+	20.7	3.7	10.37	6.1
Total	100.0	100.0	100.00	59.2

$$(3) = \frac{(1) \times (2)}{\Sigma (1 \times 2)}$$

*-Refers to next years model introduced in the Fall.
**-This percent reflects the fact that some vehicles in this age category have not been driven for a full year.

Heavy Vehicles	Vehicle Miles of Travel	Percent of Total Vehicle Miles of Travel
Medium and Heavy Trucks	14,800	2.0
Buses	44,400	6.0
Total	59,200	8.0

PHILADELPHIA TRAVEL AND VEHICLE CLASS ESTIMATES

Travel Estimates

Estimates of vehicle miles of travel within Philadelphia and its central business district were based principally on historical projections. City-wide travel was based on known 1960 traffic, projected by trends in auto ownership and screen line crossings. Travel within the central business district was based on trends reflected by cordon counts taken on its perimeter as well as a 1963 traffic flow map.

During 1960, a complete inventory of travel data was made in conjunction with the Penn-Jersey Transportation Study. These data also provided the basis for planning by the Delaware Valley Regional Planning commission and form the basis for establishing travel within the City. Actual growth reflected by census, interim traffic counts, available real life data, and judgement was used to estimate 1970 and 1977 travel from this base year.

Citywide Travel

During 1960 the existing major street system (expressways, major and minor arterials) within the City accommodated 7,284,000 vehicle miles of travel a day. The remaining local street system carried an estimated 1,758,000 vehicle miles of travel,providing a total 9,042,000 (1) vehicle miles of travel within the City.

Auto ownership increased from 400,000 to 463,200 (or 15.8 percent) between 1960 and 1970.(2) Traffic volumes crossing an internal screen line in north Philadelphia--generally following Allegheny Avenue, the Penn-Central Railroad and Frankfort Creek between the Schuylkill and Delaware Rivers--indicated a traffic growth of 19.1 percent from 1960 to 1970.(3)

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(1) - Delaware Valley Regional Planning Commission

(2) - Census and R. L. Polk Company data.

(3) - Delaware Valley Regional Planning Commission -- unpublished screen line study.

It is expected that auto ownership and traffic in Philadelphia will increase at a lower rate in the future.

Travel within the City was estimated to have increased 17.5 percent between 1960 and 1970, or an average rate of 1.75 percent per year. For the seven-year period 1970 to 1977 it is estimated to increase 11.2 percent, or on the average of 1.60 percent per year. Excluding the effects of diversion possibly due to new freeways (discussed later) or significant changes in transit use, the following estimates of vehicle miles of travel (VMT) on a daily basis were made:

DAILY VEHICLE MILES OF TRAVEL

	1960	1970	1977
Major Highway System	7,284,000	8,550,000	9,500,000
Local Streets	1,758,000	2,050,000	2,300,000
Total	9,042,000	10,600,000	11,800,000

Average speed on the major street system in 1960 was 20.5 miles per hour.(1) An average speed of 12 miles per hour was assumed on the local streets.

A travel time survey made by the DVRPC over selected routes within the region indicates a slight overall decrease in speeds on the Pennsylvania routes between 1960 and 1971. Within the City the speed on the major street system was assumed to be 20 miles per hour with the same 12 miles per hour applicable on local streets. The weighted overall average speed was calculated at 18.5 miles per hour as follows:

	Average Speed	VMT	Average Speed x VMT
Major Streets	20	8,550,000	171,000,000
Local Streets	12	2,050,000	24,600,000
		10,600,000	195,600,000

$$\frac{195,600,000}{10,600,000} = 18.5 \text{ miles per hour}$$

(1)-Delaware Valley Regional Planning Commission.

If no major highway or TOPICS improvements were made by 1977, it is estimated that the average overall speed within the City would be reduced to 17.5 miles per hour. The implementation of several TOPICS projects and completion of the following sections of expressway and river bridges indicates about a 20 mph overall speed will be maintained under 1977 traffic volumes:

I-95 (Delaware Expressway) throughout City and southerly to Chester.

I-76 (Vine Street Expressway)

I-476 (Mid-County Expressway)

Industrial Expressway-26th Street Connector interchange

Chester and Delair Bridges

I-295 throughout region in New Jersey

I-76 connection to Ben Franklin Bridge in New Jersey

The diversion of about 100,000 VMT from the City is expected with the completion of the Mid-County Expressway and the Chester Bridge--most of the diversion resulted from completion of the Mid-County Expressway. As a measure of expected improved operations under highway or TOPICS projects in relation to Citywide operations, the following were assumed:

- The expected increase in speed would be applied to the traffic volume on the facility before the improvement was made and would be equivalent to the overall improved operations.

- No change would be made in the overall vehicle miles of travel.

For example, a before study on a TOPICS project indicates that average speed along a four-mile section of highway carrying 15,000 vehicles a day is 20 miles per hour. TOPICS improvements are estimated to increase the speed three miles per hour. The product of the VMT (4.0 x 15,000) times the increase in average speed (three mph) would be 180,000 VM^2/hr. This would afford an increment of improvement that can be related to the speed improvement for the overall system.

Say overall system carries 1,000,000 vehicle miles of travel at an average speed of 15 mph. The improvement would raise the average speed as follows:

Areawide: 1,000,000 x 15 = 15,000,000
Product increase due to TOPICS 180,000
15,180,000 VM^2/hr.

New average speed = $\frac{15,180,000}{1,000,000}$ = 15.2 mph

Traffic diverted out of the city was assumed to have an equivalent effect of increasing the speed on a given highway. Traffic on a newly opened facility was assumed to afford an addition equal to its use and estimated speed.

The overall effects of both highway construction and TOPICS improvements expected by 1977 are summarized as follows:

	VMT	Average Speed	VMT X Average Speed Product
Base travel	11,700,000	17.5 mph	204,750,000
Freeway and Bridge Improvements			+21,530,000
TOPICS improvements			+ 6,565,000
Total	11,700,000	19.9 mph	232,845,000

Increments of improvement are for the various highway improvements shown in Table B-9.

CBD Travel

The City of Philadelphia Traffic Engineering unit made cordon counts in 1959, 1963, and 1970 of all vehicles entering and leaving the city center bounded by the Schuylkill and Delaware Rivers on the west and east, Spring Garden Street on the north and South Street on the south. Daily traffic volumes on all streets within this cordon were also counted in 1963.

Table B-9

VMT - SPEED PRODUCT INCREASES
ATTRIBUTABLE TO HIGHWAY AND TOPICS IMPROVEMENTS

Improvement	VMT	Increase in Average Speed (mph)	Increase in VMT x Speed
Highway			
Completion I-95 (Delaware Expressway)	420,000	40*	16,800,000
Vine Street Expressway	140,000	10	1,400,000
I-476 (Mid-County Expressway)**	710,000	2	1,420,000
Industrial Expressway-26th Street Connector (Interchange)	104,000	15	1,560,000
Chester Bridge***	350,000	1	350,000
Highway Improvements Total			21,530,000
TOPICS			
CBD Core	125,000	3	375,000
CBD Fringe	380,000	5	1,900,000
Broad Street			
South	76,000	8	608,000
North	304,000	3	912,000
City Line Avenue	143,500	4	574,000
Walnut-Chestnut Street (West of Schuylkill River)	136,000	3	408,000
Roosevelt Boulevard	840,000	2	1,680,000
Huntington Park Avenue	54,000	2	108,000
TOPICS Total			6,565,000
Grand Total			28,095,000

*-Estimated equivalent to providing 40 mph operation on 6 miles of new facility carrying 70,000 vehicles per day.

**-Estimated equivalent to reducing travel on the Schuylkill Expressway by 10,000 vehicles per day, affording a two mph speed increase.

***-Estimated equivalent to reducing travel on south route (Walt Whitman Bridge-Penrose Avenue) through Philadelphia by 2,000 vehicles per day, affording an average one mph speed increase.

The total daily volumes entering (or leaving) during the three years were as follows:

Year	Vehicles Entering (or Leaving) CBD
1959	320,000
1963	300,000
1970	320,000

The drop in CBD traffic between 1959 and 1963 is principally attributable to the completion of the Schuylkill Expressway during this period. It is estimated that during the seven-year period (1970 to 1977) an additional 20,000 vehicles per day would enter and leave the CBD--equivalent to the growth in the previous seven years (1963 to 1970).

Travel in the CBD during 1963 was 637,000 VMT. Assuming that it would increase at the same rate projected for the cordon volumes, 720,000 VMT was estimated for 1977. Completion of the Delaware Expressway was estimated to add a net of 20,000 VMT to travel within the CBD. This travel made up of vehicles not now traveling in or through the CBD (diverted from routes outside the CBD--principally the Schuylkill Expressway). Gross travel of 740,000 VMT within the CBD was estimated by 1977.

Speed studies made by the City's Traffic Engineering unit in conjunction with TOPICS improvements in 1970 were used to estimate average speeds at that time on streets in the three areas of the CBD--within the Core (bounded by Locust, 18th, Race, and 7th Streets), along Vine Street-Ben Franklin Bridge route, and the fringe (including the remainder of streets within the CBD). Travel on the three parts of the street system for 1970 was assumed to be proportional to that counted in 1963. Daily VMT and average speeds in 1970 are as follows:

	VMT	Average Speed (mph)
Core Streets	136,000	8.0
Vine Street-Ben Franklin Bridge	122,000	22.0
Fringe	422,000	13.0
Total	680,000	13.6

For the year 1977, an average of 70,000 vehicles per day were assumed to use both the I-95 Expressway and the Vine Street Expressway-Ben Franklin Bridge--accounting for 235,000 of the 740,000 VMT in the CBD. The remaining 505,000 VMT was assumed to be on the core and fringe streets. Average speed on the streets was estimated assuming planned TOPICS improvements (Including the elimination of illegal parking) were implemented and the two expressways complete. Daily VMT and average speeds for 1977 are as follows:

	VMT	Average Speed
Core Streets	125,000	11.0
Vine Street Expressway-Ben Franklin Bridge	140,000	30.0
I-95	95,000	40.0
Fringe	380,000	18.0
Total	740,000	22.0

Travel by Vehicle Type

Base travel data for 1960 from the Penn-Jersey Transportation Study reports was used as a guide in estimating the proportion of travel within the City and CBD by two classes of vehicle--light duty and heavy duty. The proportion of travel by vehicle type was estimated to be the same in 1970 and 1977. The vehicles included under these two classes are:

Light duty--autos, taxis and light trucks (panels and pickups)
Heavy duty--trucks and buses

The travel on a regional basis (nine counties within the study cordon) from the Penn-Jersey Study data indicated the following:

	Percent of Daily Vehicle Miles
Autos	86.2
Taxis	0.9
Light trucks	6.3
Heavy trucks	6.6
	100.0

Citywide Vehicle Travel Distribution

Information on bus mileage was not included in the study. It was noted, however, that travel by heavy trucks was less than average in the urban areas of the region. For travel distribution purposes bus travel within the City was assumed to replace the heavy truck travel. Bus travel within Philadelphia was approximated, assuming 100 miles of travel per day by the existing 1,500 motor SEPTA bus fleet.

Taxi travel within Philadelphia was estimated assuming about 80 percent of the region's 1920 taxis operated within the City, traveling 200 miles per day.

Based on the above, vehicle miles of travel within the City of Philadelphia on a percentage basis were estimated as follows:

	Percent of Daily Travel
Light Vehicles	
Autos	85.0
Taxis	3.0
Light trucks	6.0
Subtotal	94.0
Heavy Vehicles	
Trucks	4.5
Buses	1.5
Subtotal	6.0
Total	100.0

CBD Vehicle Travel Distribution

Travel estimates in the CBD by vehicle class were based on observation and interpolation of Citywide travel. Order-of-magnitude estimates of travel in the CBD are:

	Percent of Daily Travel
Light Vehicles	
Autos	80.0
Taxis	8.0
Light trucks	4.0
Subtotal	92.0
Heavy Vehicles	
Trucks	2.0
Buses	6.0
Subtotal	8.0
Total	100.0

PUBLIC TRANSPORTATION IMPROVEMENTS

SEPTA

Near Term Completion (By 1977)

- Extension of the Broad Street subway from the Synder Avenue Station southerly to Pattison Avenue. To be opened late 1972 or early 1973.
- 144 new cars for rail commuter system (Penn-Central and Reading Companies). New cars are to be 35 percent larger than those replaced. By 1975.
- $38,000,000 for commuter parking facilities.
- Upgrade stations and extend concourses on Market-Frankford Line to accommodate eight (8)-car trains (current platforms limit train lengths to six (6) cars).
- Enhance appearance and lighting at six (6) stations on the Broad Street Line.
- Replace 900 of the 1500 motor bus fleet.
- Rehabilitate 300 of the 400 street cars ($53,000,000).
- $15.5 million to upgrade existing electric system and backup facilities.

Longer Range (By 1980)

- Replace the 130 trackless trolley bus fleet.
- Extend Market-Frankford Line to the West.
- Provide Commuter Rail Service to International Airport.
- Connect the Penn-Central and Reading rail commuter sytem -- affording through train movements.
- Begin extension of transit route to serve Northeast Philadelphia.
- $10,000,000 in commuter parking facilities.

PATCO

A. A Woodcrest Station connected to I-295 and the New Jersey Turnpike with upwards of 4000 parking spaces. Application filed with UMTA on August 11, 1971.

STATUS - Updated final application scheduled for filing with UMTA during October 1972. Local share funding likely to be available from Pennsylvania, New Jersey and the City of Philadelphia.

PROPOSED COMPLETION DATE - Late 1974 or early 1975.

COMMENTS - Requirements for bus feeder support for Lindenwold Line and Section 13-C agreements are the basic impediments to federal funding. Implementation of project is fairly certain.

B. Proposed Moorestown Line; at least 3 miles and as much as 9 miles.

STATUS - Report to Governors and Legislatures of Pennsylvania and New Jersey is being prepared.

✓ PROPOSED COMPLETION DATE - Late 1975 for 3 mile extention and late 1976 for the additional 6 mile extention.

COMMENTS - 1. Availability of local share funding not assured.
2. Requires approval of Governors of both States.

C. West Berlin; a 3 mile extension of the Philadelphia-Lindenwold Line.

STATUS - Report to the Governors and Legislatures is being prepared.

✓ PROPOSED COMPLETION DATE - Early 1976

COMMENTS - 1. Requires approval of Governors of both States.
2. Availability of local share funding not assured.

D. A new Broadway Station Transportation Center in downtown Camden with direct ramp connections to I-76 (North-South Freeway) serving primarily autos and buses from Gloucester, Salem and Cumberland Counties.

STATUS - Presently investigating cost and patronage of a facility that would meet Philadelphia-Southern New Jersey requirements.

PROPOSED COMPLETION DATE - Indefinite, dependent upon accelerated progress on I-76.

COMMENTS - Implementation is contingent upon favorable conclusions from the cost and patronage investigations

E. Morgan Blvd. Extension; a 2 mile branch off of the existing line from Division Street, Camden, to Morgan Blvd., present northern terminus of the North-South Freeway.

STATUS - If I-76 will be delayed for a prolonged period of time then this extension is a more expensive alternative for achieving an efficient interchange with I-76 for buses and autos.

The feasibility of this project is also being investigated as a part of the overall DRPA mass transit study as the first leg of the Gloucester County extension.

PROPOSED COMPLETION DATE - Indefinite

COMMENTS - Same as for Items B and C.

F. Franklin Square Station - Proposed rehabilitiation and reopening.

STATUS - If required for Bicentennial celebration, DRPA has the capability of reopening station. Federal and Commonwealth funding participation will be required.

PROPOSED COMPLETION DATE - Improvements could be accomplished within 1 to 1½ years from date funding is made available.

COMMENTS - Initiative for reopening Franklin Square must come from Bicentennial Corporation as a part of their transportation program.

G. Esthetic and environmental rehabilitation of existing subway stations utilized by PATCO in Philadelphia and Camden as differentiated from those improvements contained with UMTA project INT-UTG-10 which includes functional improvements for the existing Locust Street subway stations.

COMMENTS - All items are the same as above with the addition of the State of New Jersey as a funding participant.

PHILADELPHIA TOPICS IMPROVEMENTS

Currently under consideration and expected to be implemented by 1977 are the following TOPICS projects. Estimates of current traffic volumes and average speeds are indicated as well as estimates of speeds under improved conditions.

Central Business District

Signals on Walnut Street, Chestnut Street, Market Street, J. F. Kennedy Boulevard, Samson Street and Spring Garden Street between the Schuylkill and Delaware Rivers are proposed to be upgraded under TOPICS. In conjunction with this, the City of Philadelphia also plans to upgrade the remaining signals within the CBD. Included with the modernization of the signals is new control equipment to provide coordination during a.m., p.m., and off-hour traffic flow. Illegal parking is expected to be eliminated as part of the improvement program. Vine Street--planned to be reconstructed as an expressway by 1977--is excluded from the TOPICS improvement plan. Speed runs made by the City of Philadelphia during 1971 indicate the following average travel speeds on the CBD street system:

Within the Core	6 to 10 mph
On fringe streets	11 to 15 mph
Vine Street between 18th and 6th Streets	10 mph

TOPICS improvements are estimated to increase the average speeds from between three to five miles per hour under 1971 levels of traffic volumes. These speed increases cannot be attained unless the illegal parking is eliminated.

Broad Street

Signal improvements and incorporation of a raised median on portions of Broad Street--throughout its length within the City are proposed as TOPICS improvements.

South of City Hall the signals are very old and have no coordination. Average speeds are estimated to be within the range of 8 to 12 mph. In addition to upgrading the signal installations, they will be interconnected and timed to provide progression favoring a.m., p.m., and off-hour traffic flow. Progressive timing should double the existing average speeds to between 12 and 20 mph.

Average traffic volumes on Broad Street, south of City Hall are in the order of 20,000 vehicles per day.

North of City Hall the Broad Street signals are interconnected affording average overall speeds in the order of 20 mph. Their upgrading is expected to afford a two to three mph increase in average speed under current weekday volumes averaging in the order of 40,000 vehicles per day on this route.

City Line Avenue

TOPICS type improvements are to be made on City Line Avenue between the Schuylkill Expressway and the west City Limits (Cobb's Creek) including upgrading signalization, minor changes in channelization, and other traffic engineering improvements. Estimated average speeds on this street under current average traffic volumes of 35,000 vehicles per day is 20 mph. Under the same traffic volumes the improvements are estimated to increase the average speed three to five miles per hour.

Walnut Street-Chestnut Street

West of the City Center--between the Schuylkill Expressway and Cobb's Creek--upgrading signalization coordination, signal visibility, and other traffic operational features along the Walnut Street-Chestnut Street one-way couplet under a TOPICS project are expected to be implemented by 1974. The couplet accommodates an average of about 40,000 vehicles per day at an average speed of 19 miles per hour. Existing improvements are estimated to increase the average speed to 22 mph.

Roosevelt Boulevard

Traffic engineering improvements along Roosevelt Boulevard from Hunting Park Avenue to the Bucks County line under TOPICS are under study and expected to be implemented by 1977. Average daily traffic volumes on sections of this facility vary from 50,000 to 120,000 vehicles per day with estimated average speeds varying from 20 to 35 miles per hour along its 12-mile length. Throughout its length, it accommodates an average of 70,000 vehicles per day at an estimated average speed of 27 miles per hour. It has been assumed that the TOPICS improvements will effect about a two miles per hour increase in average overall speed under the same traffic volumes.

Hunting Park Avenue

Signalization and traffic engineering improvements on Hunting Park Avenue between East River Drive and Roosevelt Boulevard under TOPICS are anticipated by 1977. Current traffic volumes average 20,000 vehicles per day. Estimated average speed over this route is assumed to increase in the order of ten percent (from 18 to 20 miles per hour) with the TOPICS improvements.

Schuylkill Expressway

TOPICS improvements--principally to improve safety and provide traffic condition information to motorists--are soon to be implemented. They include the installation of impact alternators at selected exit noses, improvement of slippery pavement texture and illumination in 30th Street underpass (Penn-Central Station), and changeable message signs to indicate the degree of congestion on sections of Expressway. Traffic on three high-volume ramps also is to be metered to decrease merging turbulance during peak periods of the day. This is expected to improve flow on the Schuylkill but may add congestion to adjacent streets as well as increase the backup of traffic on the ramps waiting to gain access. The net overall effect, in terms of vehicle miles of travel and average speed, is unestimable at this time.

PHILADELPHIA POLLUTION STUDY
Auto Travel-Transit Rider Relationships

To establish a guide in estimating the reduction in auto travel (VMT) that might be expected, assuming auto riders could be shifted to transit, the relationship that existed in 1960 (when such base data were available) was examined.

Order-of-magnitude relationships indicate that, on a citywide basis, for every 10 percent increase in transit ridership (formerly persons using autos) a reduction of vehicle miles of travel of about 5 percent would occur. See Table B-10

Within the CBD, a 10 percent increase in transit ridership (trips to and from this area) would afford a reduction in auto travel in the order of 7 percent. See Table B-11

Mode split data quantifying current auto-transit relationships are unavailable and, thus, would be subject to more extensive study (beyond the scope of this report). However, as a guide, an order-of-magnitude ratio of 2 to 1 (percent increase in transit ridership made up of auto passengers to percent decrease in motor vehicle miles of auto travel) appears applicable to Philadelphia and its CBD.

PHILADELPHIA POLLUTION STUDY

Auto Travel-Transit Rider Relationships
(Alternative Analysis)

To establish order of magnitude reliance on the foregoing analysis, a similar analysis was made assuming that improvements in mass transit control measures would focus on work trips. The results seem to indicate that the average work trip is somewhat longer than the average of all trip types and thus higher reductions in VMT per trip diversion are indicated.

Included in the 1970 census[1] are work trips originating in the area by mode and by origin-destination. Extracting Philadelphia origin-destination work trips from the data, it is estimated that about 491,000 work trips are by auto and 370,000 are by public transportation. Table B-12 is an example of the effect on VMT from a 10 percent increase in mass transit ridership due to diversion from vehicle trips.

(1) "1970 Census of Population and Housing. Census Tract. Philadelphia, Pennsylvania - New Jersey Standard Metropolitan Statistical Area."

Table B-10

PHILADELPHIA - CITYWIDE

ORDER-OF-MAGNITUDE
TRANSIT RIDERSHIP-AUTO TRAVEL RELATIONSHIPS
Based on the Proportion of 1960 Internal Trip Origins[a]

	Trip Origins Within the City (in thousands)		
	1960 Base	With 10% Increase in Transit	Persons Per Auto
Transit Person Trips[b]	1,020	1,125	
Auto Person Trips[c]	2,305	2,200	1.47
Auto Driver Trips[c] (automobile trips)	1,570	1,500	1.47

Decrease in Automobile Trips $\simeq$ Decrease in Auto VMT[d]

$$\frac{70,000}{1,570,000} = 4.5 \quad \text{Say 5 percent}$$

(a) Penn Jersey Volume 1 Study Report and 1985 Regional Transportation Plan (Report No. 5, Delaware Valley Regional Planning Commission)
(b) Includes commuter railroad, rapid transit, surface bus and trolley lines.
(c) Excludes taxi and truck trips.
(d) Disregards through auto trips, assumed to be less than 10 percent of VMT within the City.

Table B-11

PHILADELPHIA - CENTRAL BUSINESS DISTRICT

ORDER-OF-MAGNITUDE TRANSIT RIDERSHIP-AUTO TRAVEL RELATIONSHIPS
Based on the Proportion of 1960 Internal Trip Origins[a]

	Trips with Origins and Destinations in the CBD[b] (in thousands)		
	1960 Base	With 10% Increase in Transit	Persons Per Auto
Transit Person Trips[c]	460	505	
Auto Person Trips[d]	350	305	1.4
Auto Driver Trips[d] (automobile trips)	250	218	1.4

Decrease in Automobile Trips with Origins and Destinations in CBD $= \frac{32,000}{250,000} = 12.8\%$

Estimated Proportion of Auto Travel Attributable to Through Trips (Equivalent to 115,000 through vehicles[e] traveling twice the distance of those with origins and destinations in the CBD) 48%

$(1 - 0.48) \times$ Decrease in CBD Oriented Automobile Trips $\cong$ Decrease in Auto VMT

$0.52 \times 12.8\% \cong 6.7\%$ Say 7 percent

(a) Penn Jersey Volume 1 Study Report and 1985 Regional Transportation Plan (Report No. 5, Delaware Valley Regional Planning Commission.

(b) Assumes trip destinations in CBD equal trip origins and a negligible proportion of the auto and transit trips have both their origin and destination within the CBD.

(c) Includes commuter railroad, rapid transit, surface bus and trolley lines.

(d) Excludes taxi and truck trips.

(e) Approximated from 1963 CBD cordon counts.

Table B-12

PHILADELPHIA - CITYWIDE

ORDER-OF-MAGNITUDE
TRANSIT RIDERSHIP - AUTO TRAVEL RELATIONSHIPS
Based on Work Trips Into or Out Of City

	1970 Base	With 10% Increase in Transit	Change
Transit Work Trips	370,000	407,000	37,000
Auto Work Trips	491,000	454,000	37,000
Auto Driver Work Trips	409,000	378,000	31,000

Decrease in automobile trips = Decrease in Auto VMT

$$\frac{31,000}{409,000} = 0.08 \text{ (8 percent)}$$

APPENDIX C
CONTACT AND DOCUMENTATION LIST

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22. Act No. 154, approved by State legislature June 16, 1972, Effective September 15, 1972.

23. Air Management Services, City of Philadelphia, Control of Vehicular Air Pollution in a Comprehensive Program, November 3, 1972.

LIST OF CONTACTS

FEDERAL

- EPA Region III
- EPA Land Use Planning Branch
- Postal Service

STATE

- Pennsylvania Department of Environmental Resources
- Pennsylvania Department of Transportation
  - Bureau of Traffic Safety
  - District Engineer
  - Deputy Secretary for Planning
  - Deputy Secretary for Local and Area Transportation
- New Jersey Department of Transportation
- New Jersey Department of Environmental Protection

REGIONAL

- Delaware Valley Regional Planning Commission (DVRPC)
- Southeastern Pennsylvania Transit Authority (SEPTA)
- Delaware River Port Authority (DRPA)

CITY

- Air Management Services
- Department of Public Property
- Streets Department
- City Planning Commission
- Parking Authority
- Police Department
- Traffic Engineering Division
- Mayor's Science and Technology Advisory Council

CITIZEN GROUPS

Citizens Advisory Council
Delaware Valley Citizens' Council for Clean Air
Transportation Action Group

INDUSTRY/COMMERCIAL

Greater Philadelphia Chamber of Commerce
Yellow Cab Company

AUTO AIR POLLUTION QUESTIONNAIRE
PHILADELPHIA METROPOLITAN AREA

The questionnaire shown in Figure D-1 was sent to a panel of residents of the Philadelphia Metropolitan Area to obtain their views on factors affecting auto air pollution and potential control measures. A total of 178 usable questionnaires were returned. The sample was selected by Consumer Mail Panels to be representative of the population of the area in terms of income level and age. Annual family income (1971) of respondents was:

Less than $8,000	22%
$8,000-$15,000	52%
More than $15,000	26%

Their home locations were distributed as follows throughout the metropolitan area:

Location	Number of Respondents	Percent of Total
City of Philadelphia	71	40
Towns in Metropolitan Philadelphia - Pennsylvania Suburbs	74	42
Towns in Metropolitan Philadelphia - New Jersey Suburbs	33	18
	178	100

Each respondent was asked to indicate the number of autos owned in his household. Answers were as follows:

No car	6%
One car	39%
Two cars	47%
Three or more cars	8%

Questionnaire responses were tabulated by income level and car ownership of each panel member's family. Results of the survey follow with appropriate explanatory notes.

1. All autos made in 1975 and thereafter will be equipped with emmision control devices to reduce air pollution. If in 1975 you owned a car built before that year, how would you feel about a law requiring you to put emission control equipment which might cost $200 on your car? ("X" BELOW)

2. How would you feel about this law if the cost was reduced by government subsidy to about $50? ("X" BELOW)

Feeling Toward Law:	1. Cost $200	2. Cost $50
Very much in favor of law..	11.8%	62.2%
Somewhat in favor of law...	29.9	22.7
Somewhat against law.....	18.1	6.4
Very much against law.....	40.3	8.7

3a. Even cars properly equipped with emmision control equipment might still pollute the air if the equipment was not properly maintained, How would you feel about a law requiring periodic inspection of the emission control system to assure that it was working properly? ("X" ONE ONLY)

Very much in favor of law	Somewhat in favor of law	Somewhat against law	Very much against law
61.2%	30.9%	3.9%	3.9%

3b. Assuming you had to have your car inspected at least once a year, what would you consider a reasonable cost for the inspection? (WRITE IN AMOUNT)

$ 7.02 (Avg.)

Of 18 respondents who answered "nothing" to this question, 15 resided in the New Jersey portion of the metropolitan area where there is already an inspection program. The mean value given by all respondents who owned one or more cars was approximately $6.95. The following is a tabulation of the mean value by car ownership status of the panel member's family:

No car	$9.44
One car	6.75
Two cars	7.12
Three or more cars	6.77

3c. **Assuming you <u>had</u> to have your car inspected at least once a year, where do you think the inspection should be made? ("X" ONE ONLY)**

At state-operated inspection centers.....	61.8%
At city-operated inspection centers.....	3.4
At local service stations or garages.....	31.5
At some other place (Specify):	3.4

4a. Even if all autos were equipped with properly maintained emission control systems, some cities might still have auto air pollution problems due to the large number of cars either on the streets at the same time or concentrated in particular areas. Listed below are several possible ways to reduce pollution under one or both of these conditions. Please tell me how you feel about <u>each</u> of these proposals. ("X" ONE ON EACH LINE)

Proposal	To Me This Plan Is: Very Acceptable (+2)	Somewhat Acceptable (+1)	Neither Acceptable Nor Unacceptable (0)	Somewhat Unacceptable (-1)	Very Unacceptable (-2)
a. Gasoline rationing	2.3%	7.6%	4.7%	11.6%	73.8% ▲
b. Very high ($500) registration fee per auto	-	1.7	1.1	8.5	88.6 ▲
c. Very high ($500) registration fee per auto but only for the second, third, etc., auto	5.8	7.0	4.7	13.5	69.0 ▲
d. Prohibit traffic and parking in central business districts	30.6	32.9 ▲	9.8	15.0	11.6
e. A tax on <u>all day</u> parking in central business districts	17.1	24.6	10.9	15.4 ▲	32.0
f. A tax on parking in central business districts regardless of whether a person parked only one hour or all day	4.6	20.2	12.1	17.3 ▲	45.7
g. Tolls on exit ramps of major freeways and expressways	1.1	10.9	14.4	16.7	56.9 ▲
h. Tolls on exit ramps of major freeways and expressways but only when traffic was heavy	1.7	9.8	14.4	16.1	58.0 ▲
i. Restrictions on non-essential auto travel during times of high pollution by issuance of special license plates or vehicle stickers	11.9	21.6	17.0	13.1 ▲	36.4
j. Turn some existing lanes into "bus only" and "car pool only" lanes on major expressways and streets	31.6	34.5 ▲	10.9	9.2	13.8

▲- Indicates the weighted mean for each answer.

In general, the level of acceptability of each proposal decreased with greater car ownership. Families owning two or more cars were usually more opposed to the control measures than those with fewer cars owned in their household.

4b. Which of the proposals listed above would be the most acceptable? (Give Letter:) D - 38.4%
J - 30.2

4c. Which would be most unacceptable? ..... (Give Letter:) B - 60.9%
A - 29.9

QUESTIONS 5-8 ASK FOR INFORMATION RELATING TO OTHER HOUSEHOLD MEMBERS. CONSULT THEM, IF NECESSARY, FOR THE ANSWERS.

5a. How often do the various members of your household travel by public transportation? (For example, by bus, subway, or commuter train.)

	Husband (158R)*	Wife (174R)	Children (Over 16 Years Old) (105R)
Three or more times a week.	12.0%	13.8%	17.1%
One or two times a week.....	3.8	6.3	2.9
Once a month.....	3.8	8.6	4.8
Once every three months	14.6	22.4	5.7
Never	62.7	48.9	25.7
No household member	3.2	-	43.8

*-(158R) = 158 respondents in this category.

5b. Please rate each household member's reason for using public transportation. (Rate the most important reason "1", the next most important "2", the next "3", etc. If a household member never uses public transportation, "X" the "never use" box at the bottom of the list.)

5c. Please rate each household member's reasons for traveling by auto. Follow the same procedure as in Question 5b. (WRITE IN BELOW UNDER 5c)

CONCENSUS RATING

Reasons	5b. Public Transportation			5c. Auto Transportation		
	Husband	Wife	Children (Over 16 Years Old)	Husband	Wife	Children (Over 16 Years Old)
a. Cheaper	1	6	3	6	6	6
b. Faster	2	3	1	3	3	2
c. More comfortable	7	10	8	4	4	4
d. Safer for passenger.	7	9	5	8	8	7
e. Less congested.	3	8	6	7	6	5
f. More available	5	2	2	2	2	1
g. More flexible (I can come and go as I please).	10	7	8	1	1	2
h. More relaxing (able to read while traveling).	4	5	10	----NOT APPLICABLE-----		
i. Need car during the day.	-----NOT APPLICABLE-----			5	5	8
j. I do not have a driver's license.	9	1	7	----NOT APPLICABLE-----		
k. Car is not available when I need it.	6	3	4	----NOT APPLICABLE-----		
l. Other (Specify): _____						
m. Never use ("X" Box)	99/193	85/174	27/59	4/153	10/174	7/59

There were very few "other" reasons given. Some respondents cited lack of transit service near their home as the main reason for driving.

5d. Again, consulting other members of your household, please rate in order of effectiveness which items below you feel would be most effective in encouraging the use of public transporation. (Rate the most effective item a "1", the next most effective "2", the next "3", etc.)

Items:	CONCENSUS RATING Husband	Wife	Children (Over 16 Years Old)
Cleaner and newer vehicles..	5	4	6
Faster travel	3	5	3
Air-conditioned vehicles	8	9	7
More frequent service	1	1	2
Lower fares	2	2	1
Parking facilities at stops or stations	4	7	9
Shelters against bad weather at stops or stations.....	9	8	5
Better security to assure personal safety.....	6	3	4
More conveniently located stops and stations	7	6	8

Other (Specify):

Again, there were few "other" responses, but some panel members indicated they might use public transit if there was service near their homes.

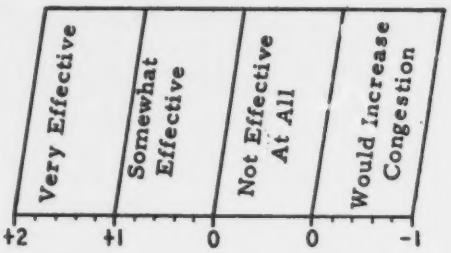
6a. How would you or other household members feel about traveling to and from work in a car pool? ("X" ONE ONLY)

Very interested	13.9%
Somewhat interested	26.5
Not at all interested	39.2
Already in car pool	6.0
Do not travel to and from work by car	14.5

6b. If it became necessary to restrict the number of cars on expressways and streets in order to reduce pollution and car pools became necessary, how difficult do you think it would be to get into one an existing one or organize one amongst your friends, neighbors and/or work associates. ("X" ONE ONLY)

Extremely difficult	32.1%
Very difficult	17.3
Somewhat difficult	31.0
Somewhat easy	7.7
Very easy	4.2
Extremely easy	3.0
Already in car pool	4.8

7. One of the major causes of areas of high pollution is traffic congestion. Pollution could be reduced if traffic congestion and stop-and-go traffic was reduced. Listed below are several ideas for reducing traffic congestion. Please tell me how effective you think each of these ideas would be in reducing congestion and pollution. ("X" ONE BOX FOR EACH IDEA)



Idea:				
a. Prohibit parking, loading and unloading on busy streets	64.3%	29.8%	5.3%	0.6%
b. Increase the number of one-way streets	13.4	54.3	23.2	9.1
c. Establish reversible lanes on busy streets to be used during rush hours	26.5	47.6	18.1	7.8
d. Prohibit turns at busy intersections during rush hours	38.9	44.3	13.2	3.6
e. Widen major streets	43.6	39.4	13.9	3.0
f. Widen major streets at intersections only	9.4	44.4	33.8	12.5
g. Provide pedestrian underpasses and/or overpasses	44.5	40.6	12.1	2.4
h. Improve timing of traffic signals	66.5	30.5	2.4	0.6
i. Increase the number and frequency of radio traffic reports	16.6	54.4	25.4	3.6
j. Turn some existing lanes into "bus only" and "car pool only" lanes on expressways and busy streets	38.2	44.2	10.3	7.3

Your ideas (Please List):

Ideas given by panel members included stricter enforcement of traffic and parking regulations and the need for buses to stop next to the curb when loading or discharging passengers. There were also some respondents who suggested that truck deliveries be scheduled during off-peak periods or that freight now being delivered by large trucks be transferred to smaller vehicles for distribution within the city.

▲- Indicates the weighted mean for each answer.

8. Since traffic congestion is most severe at times when people are going to or coming from work, one alternative for reducing congestion would be to have people start and stop work at different times of the day. That is, some people would start work at 5:00 AM and quit at 2:00 PM, others would work from 7:00 AM to 4:00 PM, others from 10:00 AM to 7:00 PM, etc. How do you feel about this idea? ("X" ONE ONLY)

Very much in favor.....	30.6%
Somewhat in favor.....	37.0
Indifferent	15.0
Somewhat opposed.....	8.1
Very much opposed.....	9.2

9a. Please record the model year of each car owned in your household. (WRITE IN BELOW UNDER 9a)

9b. Please estimate the number of miles each car was driven in the last year. (WRITE IN NUMBER OF MILES UNDER 9b BELOW)

9c. For each car, please estimate what percentage of last year's mileage was accounted for by driving outside your local metropolitan area. (For example, vacation, business trips, short weekend trips, etc.) (WRITE IN BELOW UNDER 9c)

	9a. Model Year	9b. Last Year's Mileage	9c. Percentage of Mileage Outside Local Area
Car #1	1969	12,070	33
Car #2	1967	9,703	23
Car #3	1967	12,208	31
Car #4	N/M*	N/M	N/M

*-N/M = Not meaningful because of too few responses.

9d. How many licensed drivers are there in your household? (WRITE IN)

Number of Licensed Drivers: 2.0 (Avg.)

9e. If better public transportation were available, would you consider disposing of any of the cars you own?

Yes	4.3%
Maybe	20.4
No	75.3

9f. How many? (WRITE IN) .97 cars

10a. Overall, how serious a problem do you think auto air pollution is in your city? ("X" ONE BOX UNDER 10a BELOW)

10b. Overall, how serious a problem do you think auto air pollution is nationwide? ("X" ONE BOX UNDER 10b BELOW)

	10a. City	10b. Nationwide
Very serious problem	30.9%	45.5%
Serious problem	40.0	41.3
Slightly serious problem...	24.6	12.0
No problem at all	4.6	1.2

11. If you have any views or comments regarding any question or idea, please record them:

A large number of respondents expressed their opinion that air pollution was more attributable to stationary sources (industry) and "dirty" trucks and buses than to autos. Some suggested that auto manufacturers should bear the cost of reducing air pollution. A favorable attitude toward trolley buses was expressed along with suggestions that cars be made more pollution-free by converting them to electric power or rotary engines or by improving quality of fuel. Finally, several respondents reiterated the need for additional parking at commuter railroad stations.

Figure D-1

CONSUMER MAIL PANELS
323 SOUTH FRANKLIN STREET · CHICAGO, ILLINOIS 60606

(2-C796)

Dear Panel Member,

Today, I am sending you a questionnaire which I consider both exciting and interesting. Hopefully, you will too. This questionnaire deals with the important problem of air pollution caused by automobiles.

As you know, autos are a major source of air pollution—especially in metropolitan areas. You probably have read in newspapers or magazines that auto manufacturers are being required to make changes in their cars that will reduce the amount of pollutants coming out of cars. This will be particularly true for cars manufactured in 1975 and thereafter.

Many pollution experts believe, however, that despite these new federal regulations on auto air pollution, other ways will have to be found to further reduce pollution caused by cars. The purpose of this questionnaire is to obtain your reaction to these new auto pollution control ideas being suggested by the experts. In answering some questions, you will probably have to consult other members of your family to get their ideas and reactions. I am sorry if this is inconvenient, but I am sure you will agree that the importance of solving pollution problems is worth making every reasonable effort.

As always, please check each of your answers after you have completed the questionnaire. Then return it to me in the enclosed postage-paid envelope. If you have any additional comments, please write them on the lines provided in Question 11.

Cordially,

Marie

Figure D-1 (continued)

CONSUMER MAIL PANELS

(2-C796)

AUTO AIR POLLUTION QUESTIONNAIRE

1. All autos made in 1975 and thereafter will be equipped with emmission control devices to reduce air pollution. If in 1975 you owned a car built before that year, how would you feel about a law requiring you to put emission control equipment which might cost $200 on your car? ("X" BELOW) ☐ 13

2. How would you feel about this law if the cost was reduced by government subsidy to about $50? ("X" BELOW) 14-16 Open

Feeling Toward Law:	1. Cost $200	2. Cost $50
Very much in favor of law . .	☐1	☐1
Somewhat in favor of law . . .	☐2	☐2
Somewhat against law	☐3 (17)	☐3 (18)
Very much against law	☐4	☐4

3a. Even cars properly equipped with emmission control equipment might still pollute the air if the equipment was not properly maintained. How would you feel about a law requiring periodic inspection of the emission control system to assure that it was working properly? ("X" ONE ONLY)

Very much in favor of law ☐1 Somewhat in favor of law ☐2 Somewhat against law ☐3 Very much against law ☐4 19

3b. Assuming you had to have your car inspected at least once a year, what would you consider a reasonable cost for the inspection? (WRITE IN AMOUNT)

$_____ 20 ☐☐ 21

3c. Assuming you had to have your car inspected at least once a year, where do you think the inspection should be made? ("X" ONE ONLY)

At state-operated inspection centers . ☐1
At city-operated inspection centers. . ☐2
At local service stations or garages . ☐3
At some other place (Specify): _____ ☐4 22

4a. Even if all autos were equipped with properly maintained emission control systems, some cities might still have auto air pollution problems due to the large number of cars either on the streets at the same time or concentrated in particular areas. Listed below are several possible ways to reduce pollution under one or both of these conditions. Please tell me how you feel about each of these proposals. ("X" ONE ON EACH LINE)

Proposal:	To Me This Plan Is: Very Acceptable	Somewhat Acceptable	Neither Acceptable Nor Unacceptable	Somewhat Unacceptable	Very Unacceptable	
a. Gasoline rationing	☐1	☐2	☐3	☐4	☐5	23
b. Very high ($500) registration fee per auto.	☐1	☐2	☐3	☐4	☐5	24
c. Very high ($500) registration fee per auto but only for the second, third, etc., auto	☐1	☐2	☐3	☐4	☐5	25
d. Prohibit traffic and parking in central business districts	☐1	☐2	☐3	☐4	☐5	26
e. A tax on all day parking in central business districts . .	☐1	☐2	☐3	☐4	☐5	27
f. A tax on parking in central business districts regardless of whether a person parked only one hour or all day	☐1	☐2	☐3	☐4	☐5	28
g. Tolls on exit ramps of major freeways and expressways	☐1	☐2	☐3	☐4	☐5	29
h. Tolls on exit ramps of major freeways and expressways but only when traffic was heavy.	☐1	☐2	☐3	☐4	☐5	30
i. Restrictions on non-essential auto travel during times of high pollution by issuance of special license plates or vehicle stickers	☐1	☐2	☐3	☐4	☐5	31
j. Turn some existing lanes into "bus only" and "car pool only" lanes on major expressways and streets. . . .	☐1	☐2	☐3	☐4	☐5	32

4b. Which of the proposals listed above would be the most acceptable? (Give Letter)_____ ☐ 33

4c. Which would be most unacceptable? . . . . . (Give Letter)_____ ☐ 34

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QUESTIONS 5-8 ASK FOR INFORMATION RELATING TO OTHER HOUSEHOLD MEMBERS. CONSULT THEM, IF NECESSARY, FOR THE ANSWERS.

5a. How often do the various members of your household travel by public transportation? (For example, by bus, subway, or commuter train.)

	Husband	Wife	Children (Over 16 Years Old)
Three or more times a week	...☐1	...☐1	...☐1
One or two times a week	...☐2	...☐2	...☐2
Once a month	...☐3 (35)	...☐3 (36)	...☐3 (37)
Once every three months	...☐4	...☐4	...☐4
Never	...☐5	...☐5	...☐5
No household member	...☐6	...☐6	...☐6

5b. Please rate each household member's reason for using public transportation. (Rate the most important reason "1", the next most important "2", the next "3", etc. If a household member never uses public transportation, "X" the "never use" box at the bottom of the list.)

5c. Please rate each household member's reasons for traveling by auto. Follow the same procedure as in Question 5b. (WRITE IN BELOW UNDER 5c)

Reasons:	5b. Public Transportation: Husband	Wife	Children (Over 16 Years Old)	5c. Auto Transportation: Husband	Wife	Children (Over 16 Years Old)
a. Cheaper	___(38)	___(39)	___(40)	___(41)	___(42)	___(43)
b. Faster	___(44)	___(45)	___(46)	___(47)	___(48)	___(49)
c. More comfortable	___(50)	___(51)	___(52)	___(53)	___(54)	___(55)
d. Safer for passenger	___(56)	___(57)	___(58)	___(59)	___(60)	___(61) (74-78
e. Less congested	___(62)	___(63)	___(64)	___(65)	___(66)	___(67) open)
f. More available	___(68)	___(69)	___(70)	___(71)	___(72)	___(73) 79-☐1 80
g. More flexible (I can come and go as I please)	___(15)	___(16)	___(17)	___(18)	___(19)	___(20) Cd. 2
h. More relaxing (able to read while traveling)	___(21)	___(22)	___(23)	----- (Not Applicable) -----		Dup. 1-14
i. Need car during the day	----- (Not Applicable) -----			___(24)	___(25)	___(26)
j. I do not have a driver's license	___(27)	___(28)	___(29)	----- (Not Applicable) -----		
k. Car is not available when I need it	___(30)	___(31)	___(32)	----- (Not Applicable) -----		
l. Other (Specify): _____	___(33)	___(34)	___(35)	___(36)	___(37)	___(38)
m. Never use ("X" Box)	☐1	☐2	☐3 (39)	☐1	☐2	☐3 (40)

5d. Again, consulting other members of your household, please rate in order of effectiveness which items below you feel would be most effective in encouraging the use of public transporation. (Rate the most effective item a "1", the next most effective "2", the next "3", etc.)

Items:	Husband	Wife	Children (Over 16 Years Old)
Cleaner and newer vehicles	___(41)	___(42)	___(43)
Faster travel	___(44)	___(45)	___(46)
Air-conditioned vehicles	___(47)	___(48)	___(49)
More frequent service	___(50)	___(51)	___(52)
Lower fares	___(53)	___(54)	___(55)
Parking facilities at stops or stations	___(56)	___(57)	___(58)
Shelters against bad weather at stops or stations	___(59)	___(60)	___(61)
Better security to assure personal safety	___(62)	___(63)	___(64)
More conveniently located stops or stations	___(65)	___(66)	___(67)
Other (Specify): _____	___(68)	___(69)	___(70) (71-78 open) 79-☐1 80

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6a. How would you or other household members feel about traveling to and from work in a car pool? ("X" ONE ONLY)

Cd. 3
Dup. 1-14

- Very interested . . . . . ☐1
- Somewhat interested . . . . ☐2
- Not at all interested . . . . ☐3
- Already in car pool. . . . . ☐4
- Do not travel to and from work by car. . . . . ☐5

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6b. If it became necessary to restrict the number of cars on expressways and streets in order to reduce pollution and car pools became necessary, how difficult do you think it would be to get into one an existing one or organize one amongst your friends, neighbors and/or work associates. ("X" ONE ONLY)

- Extremely difficult . . . . . ☐1
- Very difficult . . . . . ☐2
- Somewhat difficult . . . . . ☐3
- Somewhat easy . . . . . ☐4
- Very easy. . . . . ☐5
- Extremely easy . . . . . ☐6
- Already in car pool . . . . ☐7

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7. One of the major causes of areas of high pollution is traffic congestion. Pollution could be reduced if traffic congestion and stop-and-go traffic was reduced. Listed below are several ideas for reducing traffic congestion. Please tell me how effective you think each of these ideas would be in reducing congestion and pollution. ("X" ONE BOX FOR EACH IDEA)

Idea:	Very Effective	Somewhat Effective	Not Effective At All	Would Increase Congestion	
a. Prohibit parking, loading and unloading on busy streets	☐1	☐2	☐3	☐4	17
b. Increase the number of one-way streets	☐1	☐2	☐3	☐4	18
c. Establish reversible lanes on busy streets to be used during rush hours.	☐1	☐2	☐3	☐4	19
d. Prohibit turns at busy intersections during rush hours .	☐1	☐2	☐3	☐4	20
e. Widen major streets	☐1	☐2	☐3	☐4	21
f. Widen major streets at intersections only.	☐1	☐2	☐3	☐4	22
g. Provide pedestrian underpasses and/or overpasses . . .	☐1	☐2	☐3	☐4	23
h. Improve timing of traffic signals.	☐1	☐2	☐3	☐4	24
i. Increase the number and frequency of radio traffic reports	☐1	☐2	☐3	☐4	25
j. Turn some existing lanes into "bus only" and "car pool only" lanes on expressways and busy streets	☐1	☐2	☐3	☐4	26
Your Ideas (Please List):					
_____	☐1	☐2	☐3	☐4	27
_____					

8. Since traffic congestion is most severe at times when people are going to or coming from work, one alternative for reducing congestion would be to have people start and stop work at different times of the day. That is, some people would start work at 5:00 AM and quit at 2:00 PM, others would work from 7:00 AM to 4:00 PM, others from 10:00 AM to 7:00 PM, etc. How do you feel about this idea? ("X" ONE ONLY)

- Very much in favor . . . . . ☐1
- Somewhat in favor . . . . . ☐2
- Indifferent. . . . . ☐3
- Somewhat opposed . . . . . ☐4
- Very much opposed . . . . . ☐5

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(PLEASE CONTINUE ON THE NEXT PAGE)

Figure D-1 (continued)

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9a. Please record the model year of each car owned in your household. (WRITE IN BELOW UNDER 9a)

9b. Please estimate the number of miles each car was driven in the last year. (WRITE IN NUMBER OF MILES UNDER 9b BELOW)

9c. For each car, please estimate what percentage of last year's mileage was accounted for by driving outside your local metropolitan area. (For example, vacation, business trips, short weekend trips, etc.) (WRITE IN BELOW UNDER 9c)

	9a. Model Year	9b. Last Year's Mileage	9c. Percentage of Mileage Outside Local Area	
Car #1	____	_____	___%	29 ☐☐☐ 31
Car #2	____	_____	___%	32 ☐☐☐ 34
Car #3	____	_____	___%	35 ☐☐☐ 37
Car #4	____	_____	___%	38 ☐☐☐ 40

9d. How many licensed drivers are there in your household? (WRITE IN)

Number of Licensed Drivers: _____ ☐ 41

9e. If better public transportation were available, would you consider disposing of any of the cars you own?

Yes ☐1 → 9f. How many? (WRITE IN) _____ cars → 42 ☐☐ 43
Maybe ☐2
No ☐3 →

10a. Overall, how serious a problem do you think auto air pollution is in your city? ("X" ONE BOX UNDER 10a BELOW)

10b. Overall, how serious a problem do you think auto air pollution is nationwide? ("X" ONE BOX UNDER 10b BELOW)

	10a. City		10b. Nationwide	
Very serious problem.	☐1		☐1	
Serious problem	☐2	(44)	☐2	(45)
Slightly serious problem. . . .	☐3		☐3	
No problem at all.	☐4		☐4	

11. If you have any views or comments regarding any question or idea, please record them:

_____
_____
_____
_____
_____
_____
_____
_____

(46-78 open)
79 ☐☐ 80

Thank you for your help. Please check your answers and then return the questionnaire to me in the enclosed postage-paid envelope.